CPG 2-1A2
June 1973

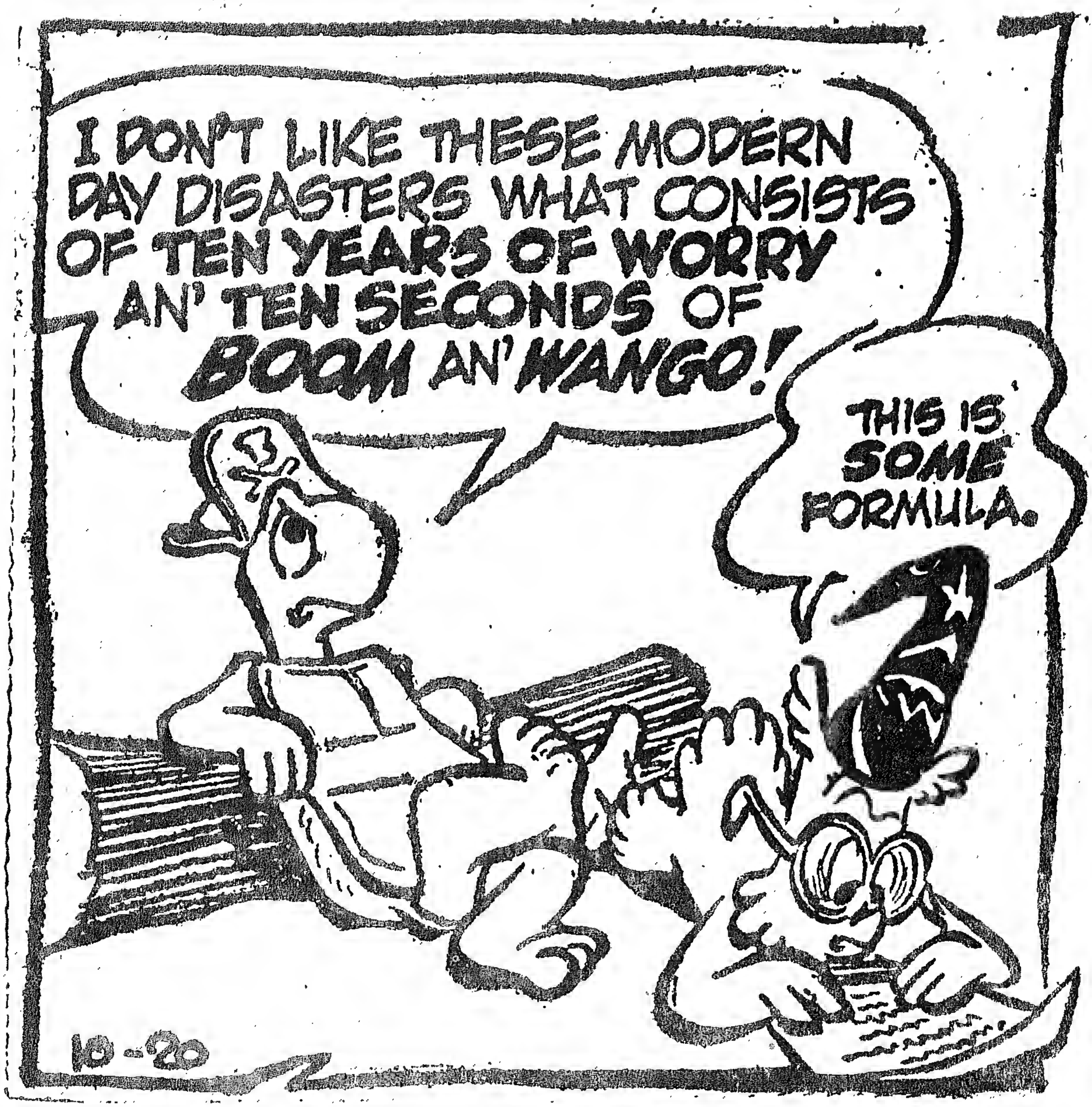
DCPA ATTACK ENVIRONMENT MANUAL

CHAPTER 2

WHAT THE PLANNER NEEDS TO KNOW
ABOUT BLAST AND SHOCK

DEFENSE CIVIL PREPAREDNESS AGENCY
DEPARTMENT OF DEFENSE

JUNE 1973


I DON'T LIKE THESE MODERN DAY DISASTERS WHAT CONSISTS OF TEN YEARS OF WORRY AN' TEN SECONDS OF BOOM AN' WANGO!
THIS IS SOME FORMULA.
10-20

PANEL 1

THE IMPORTANCE OF "LOW" OVERPRESSURES

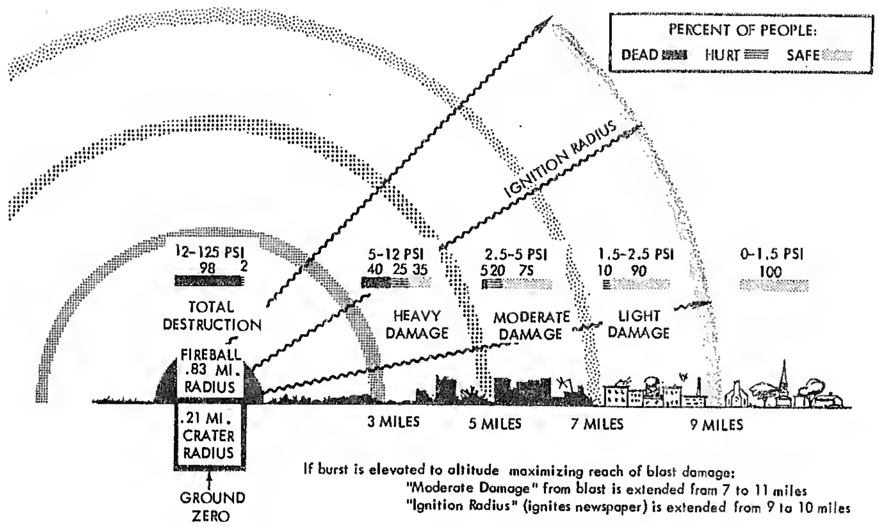
The fact that civil defense planning is largely concerned with the low overpressure region of the direct effects area should not be interpreted as concern for only a small part of the area affected by blast. Quite the contrary, most of the direct effects area is subjected to "low" overpressures. We have seen that an ability to position the population of the Detroit metropolitan area in basements with a median lethal overpressure of 12 psi would have doubled the survivors of a very heavy attack.

The importance of knowledge about the effects of low overpressure is graphically illustrated in these two sketches. The upper sketch is the picture of direct effects of a 5-MT surface burst that has been presented in OCD literature, including the Federal Civil Defense Guide, for the past 5 years. It shows the limit of light damage as extending to 9 miles from ground zero. The lower sketch is the recent revision of this effects picture. It shows light damage extending to 13 miles. This change more than doubles the direct effects area.

A close comparison of the two sketches reveals that the principal change was a downward shift of 1/2 psi in the overpressure needed to cause damage—from 2.5 psi to 2 psi for moderate damage and from 1.5 psi to 1 psi for light damage. The change came about as the result of experimental work, some of which will be described in this chapter. It is significant that such small changes in knowledge of blast effects can make such large changes in the area of coverage. The implication for emergency planning is that small changes in the vulnerability of people can make large changes in survival. Intelligent use of best available shelter can result in such changes.

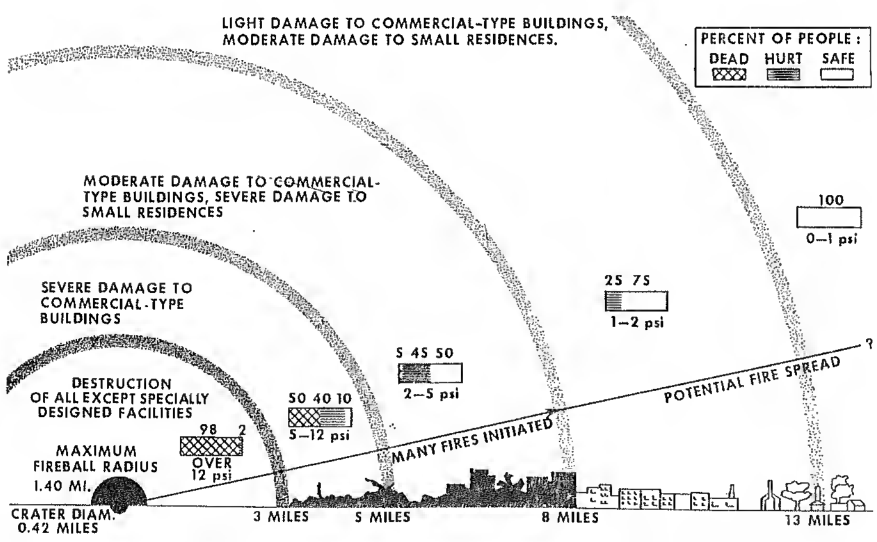
And, remember: The area covered by overpressures less than 12 psi constitutes 95 percent of the whole area experiencing at least 1 psi blast.

EFFECTS OF A 5 MT BLAST



If burst is elevated to altitude maximizing reach of blast damage:
"Moderate Damage" from blast is extended from 7 to 11 miles
"Ignition Radius" (ignites newspaper) is extended from 9 to 10 miles

DIRECT EFFECTS OF 5 MT. BLAST (SURFACE BURST)



IF BURST IS ELEVATED TO ALTITUDE MAXIMIZING THE REACH OF BLAST DAMAGE, MODERATE DAMAGE FROM BLAST AND INITIAL FIRES ON A CLEAR DAY ARE EXTENDED FROM 8 MILES TO 13 MILES.

BLAST WAVE CHARACTERISTICS
(surface burst)

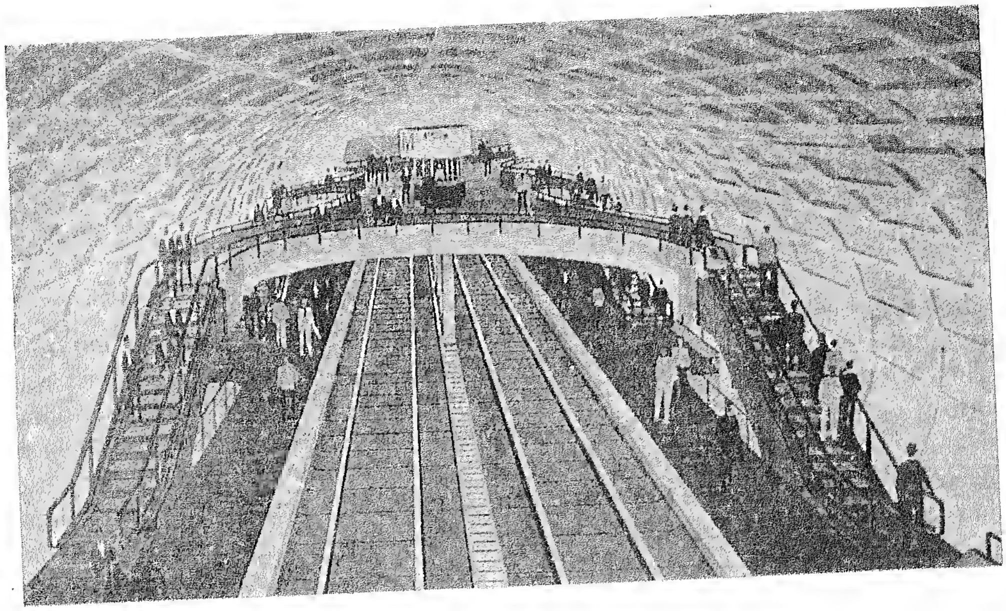
Peak Overpressure (psi)	Wind Velocity (mph)	Wind Duration for 5-MT Burst (sec)
1	35	9.5
2	70	8.5
5	160	6.8
10	290	6.0
20	470	5.8
30	670	5.6
100	1400	4.3

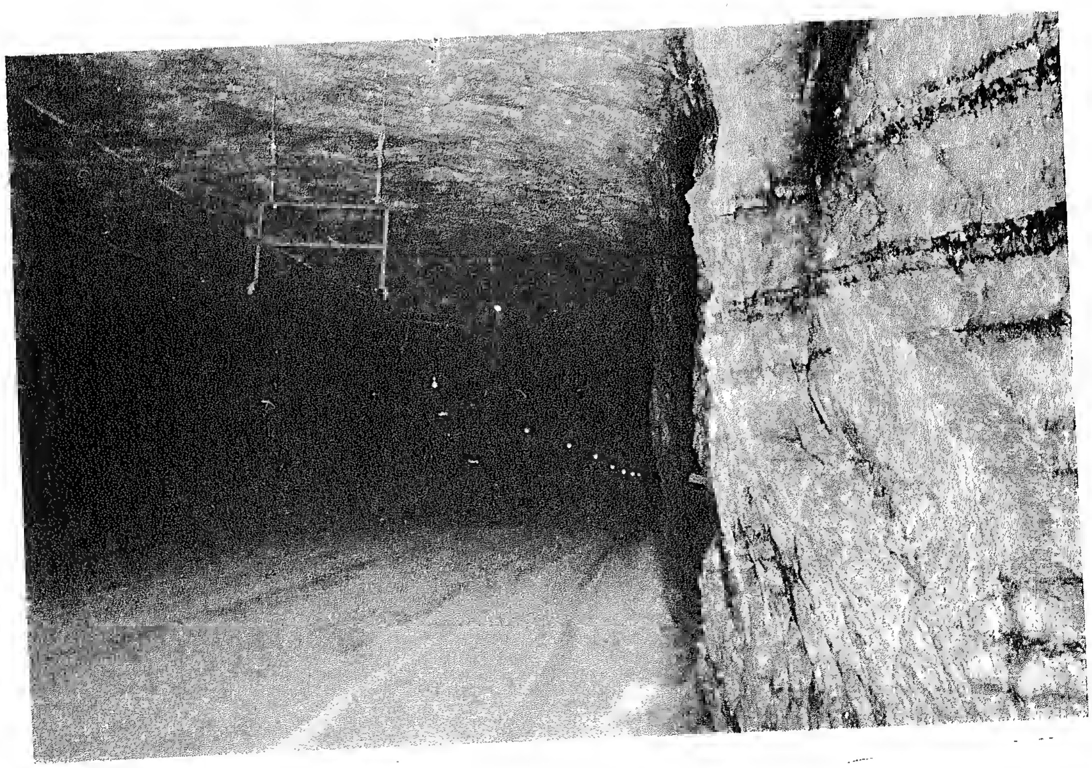
SUBWAYS, TUNNELS, MINES, AND CAVES

About 12 million fallout shelter spaces have been identified in underground areas, both man-made and natural. Nearly all of these areas offer good blast protection as well. The Soviet Union has emphasized the use of subways as blast shelters in cities. They have provided blast doors in the entrances to the subway station.

Most underground structures are stronger than building basements against blast loading. A recent analysis of a subway station being built in Washington, D.C., indicated that it could withstand an overpressure of 100 psi. Without blast doors, survival might be limited to 30 or 40 psi because of the blast wave entering through entrances and ventilation openings.

Underground subways and tunnels usually contain a large volume of air. When the blast wave enters through relatively small openings into a large-volume space, the blast wave overhead will pass by before the chamber has time to fill. This means that the pressure rise is relatively slow, which increases survival chances, and the overpressure inside may never reach the outside peak overpressure.





PANEL 18

RELATIVE BLAST PROTECTION

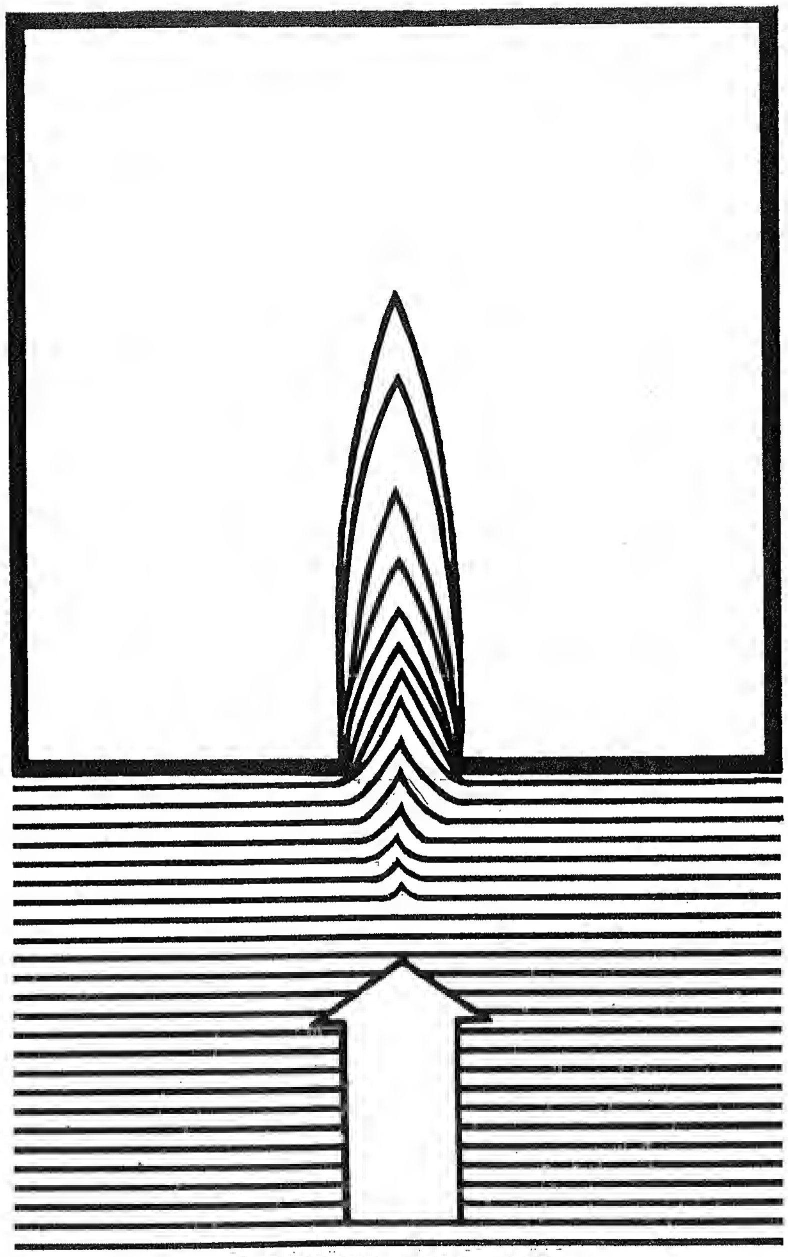
Preference	Description
A	Subway stations, tunnels mines, and caves with large volume relative to entrances.
B	Basements and sub-basements of massive (monumental) masonry buildings.
C	Basements and sub-basements of steel and reinforced-concrete framed buildings having flat slab or slab and beam ground floor construction.
D	First three floors of buildings with "strong" walls.
E	Basements of wood-frame and brick-veneer residences.
F	Fourth and higher floors of buildings with "strong" walls.
G	Basements of steel and reinforced-concrete framed buildings with flat plate ground floor.
H	First three floors of buildings with weak walls, brick buildings and residences
I	Fourth and higher floors of buildings with weak walls.

PROTECTIVE POSTURE FOR BLAST SURVIVAL

As noted previously, being thrown by the blast wind is the main source of injury and death in aboveground locations. Lying down rather than standing up is the preferred protective posture and would save many lives.

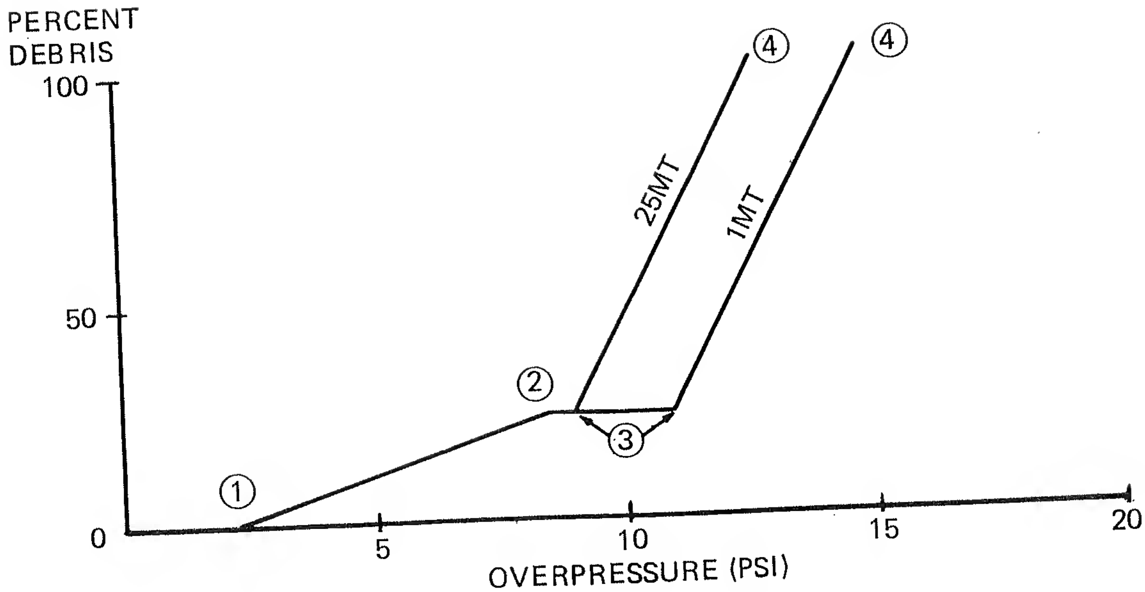
In basement areas, the hazard situation is somewhat different. People in basements will be subjected to severe wind forces only for as long as it takes the blast overpressure to fill the basement volume. The blast wave would enter through stairways, ventilation ducts, and other openings. In most basements, the filling process would be complete in several tenths of a second as compared to the several seconds of wind gust aboveground. In the vicinity of the major openings, however, the compressed air behind the shock front will rush into the shelter in the form of a high velocity air jet, as shown in the sketch.

The velocity in the jet can be sufficient to cause impact injury and death for a distance up to 10 times the width of the entranceway. In planning the use of basement areas, this hazard should be taken into account. The best location for people is near the exterior wall of the basement, out of the line of the entranceways. This location also takes advantage of the failure pattern of the ground floor over the basement. Since good basement space will usually be at a premium, people should be close-packed in a sitting position, with children sitting between the legs of adults. This protective posture can be maintained for several hours after the shelter is occupied. If people must be located in more hazardous areas, they should be encouraged to lie prone.

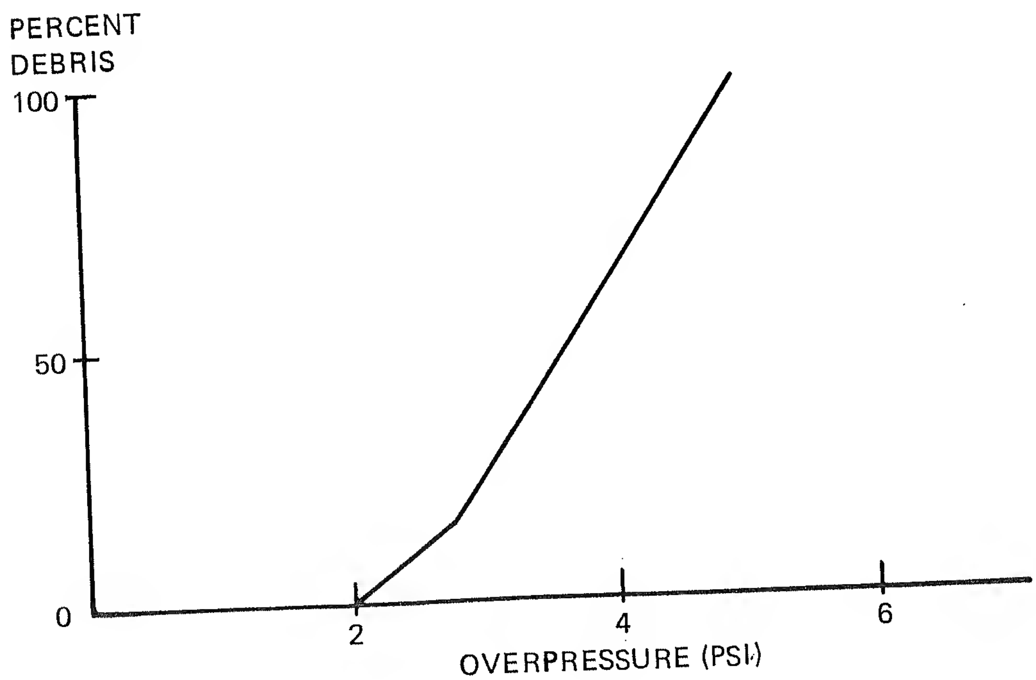


SHOCK WAVE

PANEL 20



DEBRIS CHART FOR MULTISTORY STEEL OR
R.C. FRAMED BUILDING WITH LIGHT EXTERIOR PANELS



DEBRIS CHART FOR WOOD-FRAME BUILDING

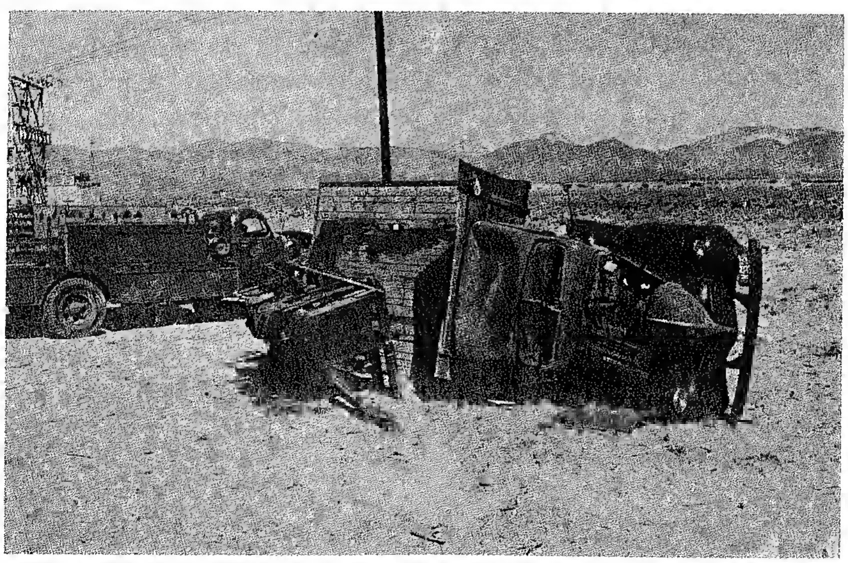
PANEL 25

TYPICAL DEBRIS DEPTHS

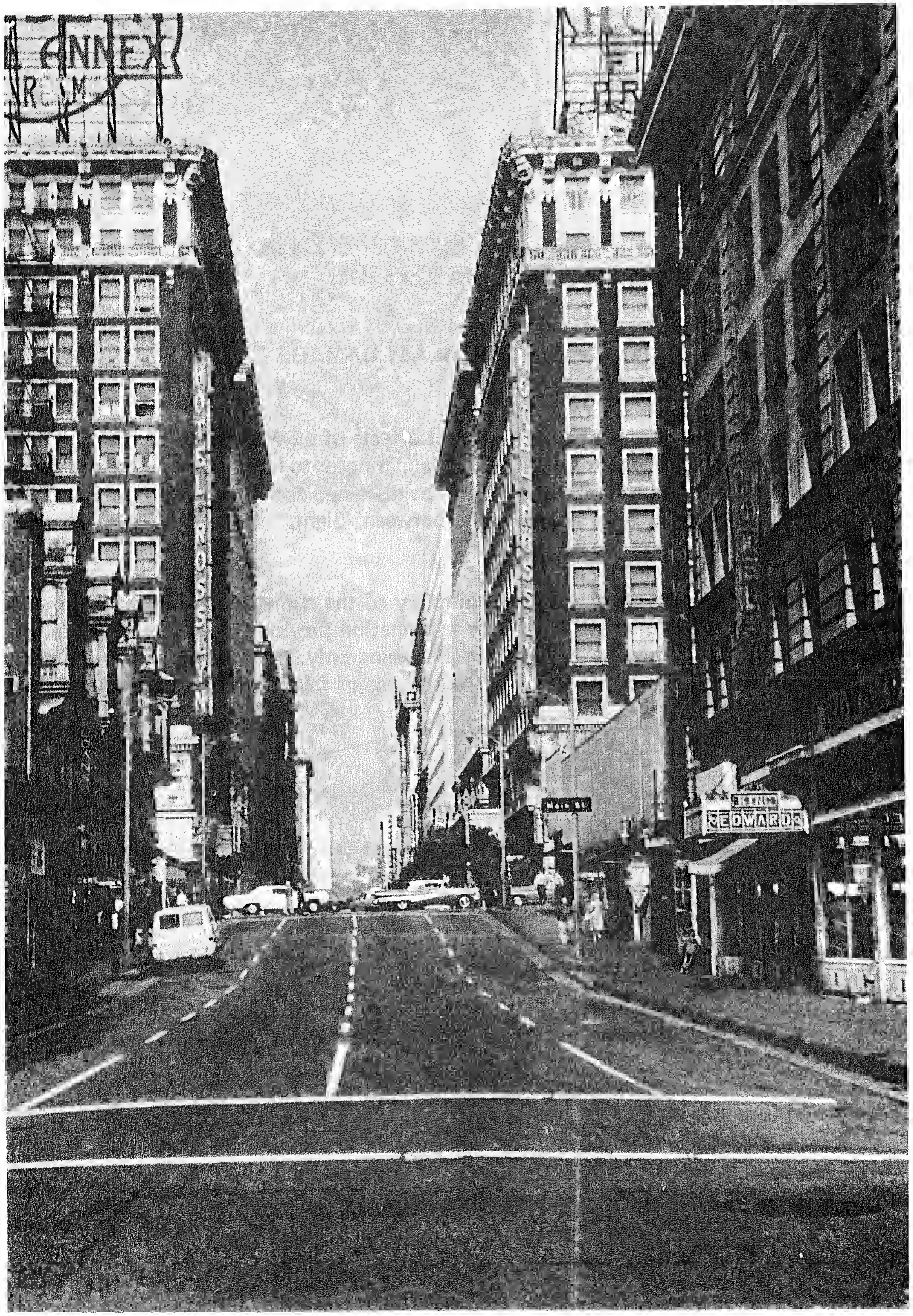
Building	Average Debris Depth (feet)
One-story Industrial	0.3
Two-story Wood-frame Residence	0.5
One-story Brick Residence	0.5
Three-story Duplex or Row House	3.0
Five-story Steel-frame Apartment House	7.0
Twenty-three-story High-rise Building	33.0

VEHICLE DAMAGE

Type	Moderate Damage (psi)	Inoperable (psi)
Automobiles	3 - 5	5 - 6
Buses	6 - 10	10 - 12
Fire Trucks	6 - 10	10 - 12
Repair Trucks	6 - 10	10 - 12
Earth and Debris Moving Equipment	20 - 30	30 - 35
Truck-Mounted Engineering Equipment	12 - 15	15 - 17
Railroad Cars	15	25
Locomotives	30	80

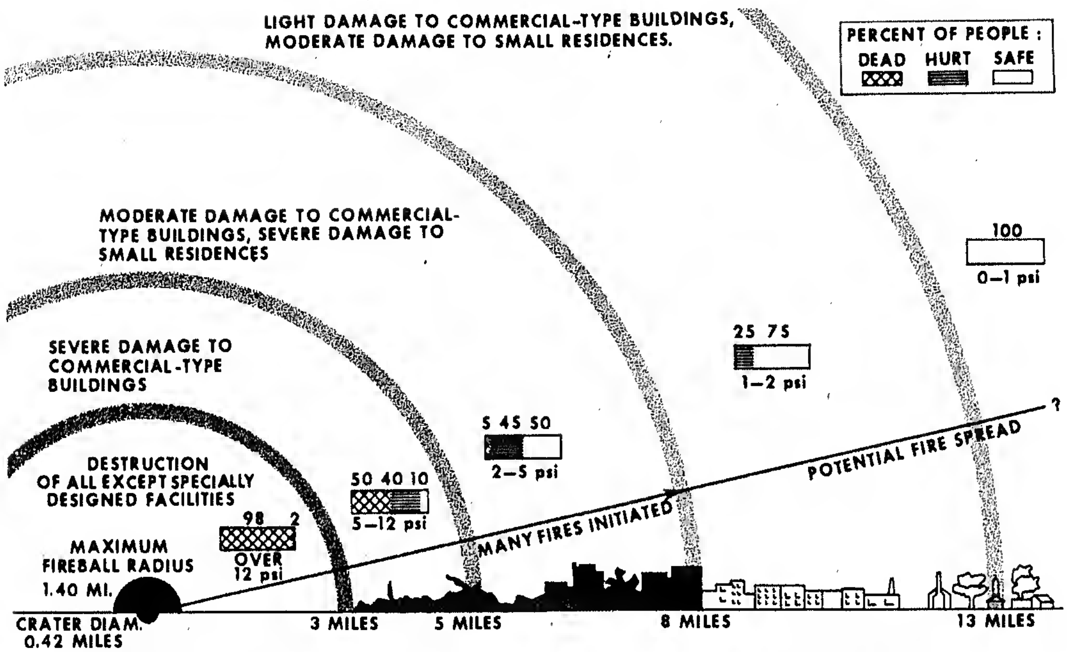


Vehicle damage at 5 psi, Nevada Test Site; both vehicles operable.

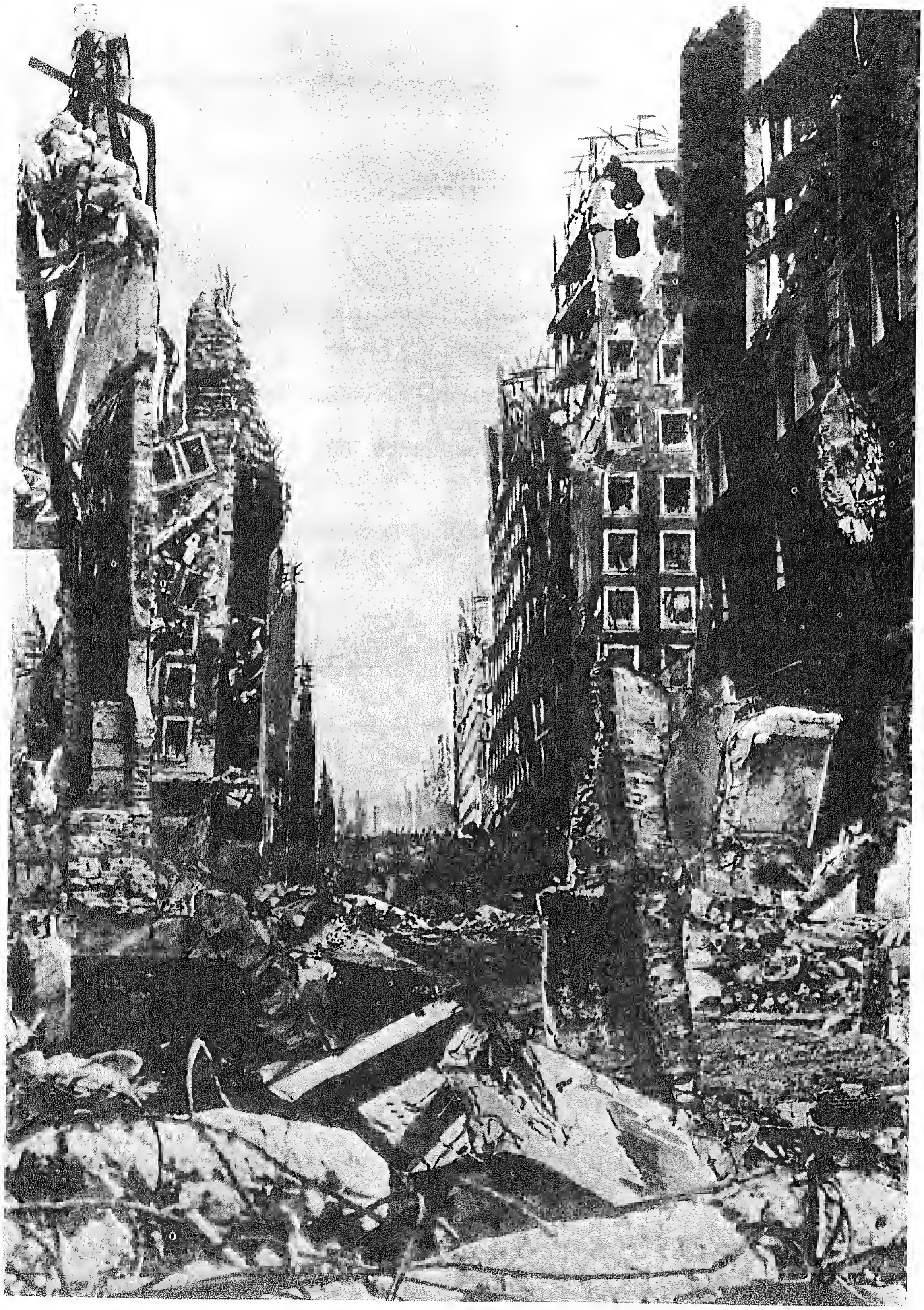


PANEL 32

DIRECT EFFECTS OF 5 MT. BLAST
(SURFACE BURST)



IF BURST IS ELEVATED TO ALTITUDE MAXIMIZING THE REACH OF BLAST DAMAGE, MODERATE DAMAGE FROM BLAST AND INITIAL FIRES ON A CLEAR DAY ARE EXTENDED FROM 8 MILES TO 13 MILES.



PANEL 36

SUGGESTED ADDITIONAL READING

The following sources provide additional background on the material in this chapter:

Effects of Nuclear Weapons, Revised Edition 1964, Glasstone, S., (editor), Chapters III, IV, V, XI, and XII, Superintendent of Documents, GPO.

Andersen, Ferd E., Jr., et al., **Design of Structures to Resist Nuclear Weapons Effects**, ASCE Manual of Engineering Practice No. 42, 345 E. 47th St., New York, New York. 1961.

Davisson, M.T., et al., **Air Force Design Manual**, University of Illinois, AFSWC-TDR-62-138, December 1962, National Technical Information Service, Springfield, Va.

Coulter, G.A., **Flow in Model Rooms Caused by Air Shock Waves**, Ballistic Research Laboratories Memorandum Report 2044, July 1970. (AD 711 885).

Wilton, C., and B. Gabrielson, **Shock Tunnel Tests of Wall Panels**, URS Research Company, January 1972. (AD 747 331).

Wiehle, C.K., and J.L. Bockholt, **Blast Response of Five NFSS Buildings**, Stanford Research Institute, October 1971. (AD 738 547).

Wiehle, C.K., and J.L. Bockholt, **Existing Structures Evaluation, Part IV. Two-Way Action Walls**, Stanford Research Institute, September 1970. (AD 719 306).

White, C.S., **The Nature of the Problems Involved in Estimating the Immediate Casualties from Nuclear Explosions**, CEX 71.1, NTIS, U.S. Department of Commerce, Springfield, Virginia.

Longinow, A., et al., **Civil Defense Shelter Options: Deliberate Shelters**, IIT Research Institute, December 1971. (Volume I, AD 740 174; Volume II, AD 740 175).

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DCPA ATTACK ENVIRONMENT MANUAL

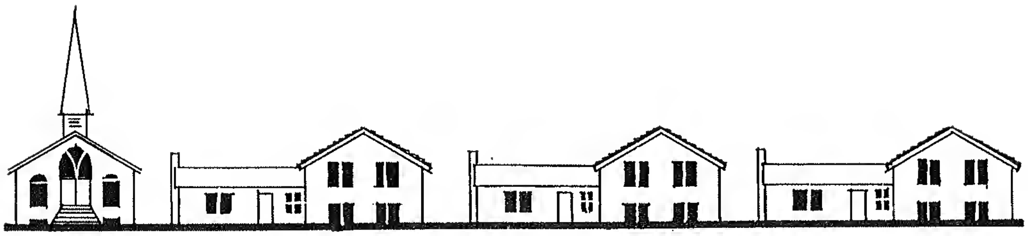
CHAPTER 3

WHAT THE PLANNER NEEDS TO KNOW
ABOUT FIRE IGNITION AND SPREAD

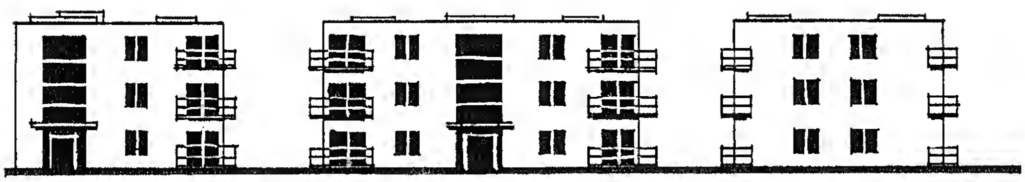
DEFENSE CIVIL PREPAREDNESS AGENCY
DEPARTMENT OF DEFENSE

JUNE 1973

LIKELIHOOD OF THERMAL SHIELDING



ONE AND TWO FAMILY HOMES — 27-34%



THREE STORY APARTMENTS — 46-54%

TENEMENTS, COMMERCIAL, HIRISE — 88-92%

PANEL 3

EFFECT OF VISIBILITY
ON TRANSMISSION OF THERMAL PULSE

Weather	Transmitted Energy
CLEAR DAY (visibility = 12 miles)	100%
LIGHT HAZE (visibility = 6 miles)	70%
MEDIUM HAZE (visibility = 3 miles)	50%
THIN FOG or LIGHT CLOUDS (visibility = 1.2 miles)	30%
HEAVY FOG (visibility less than 1/2 mile)	10%

From Gibbons, M., **Transmissivity of the Atmosphere for Thermal Radiation from Nuclear Weapons**, USNRDL, August 1966, AD 641 481.

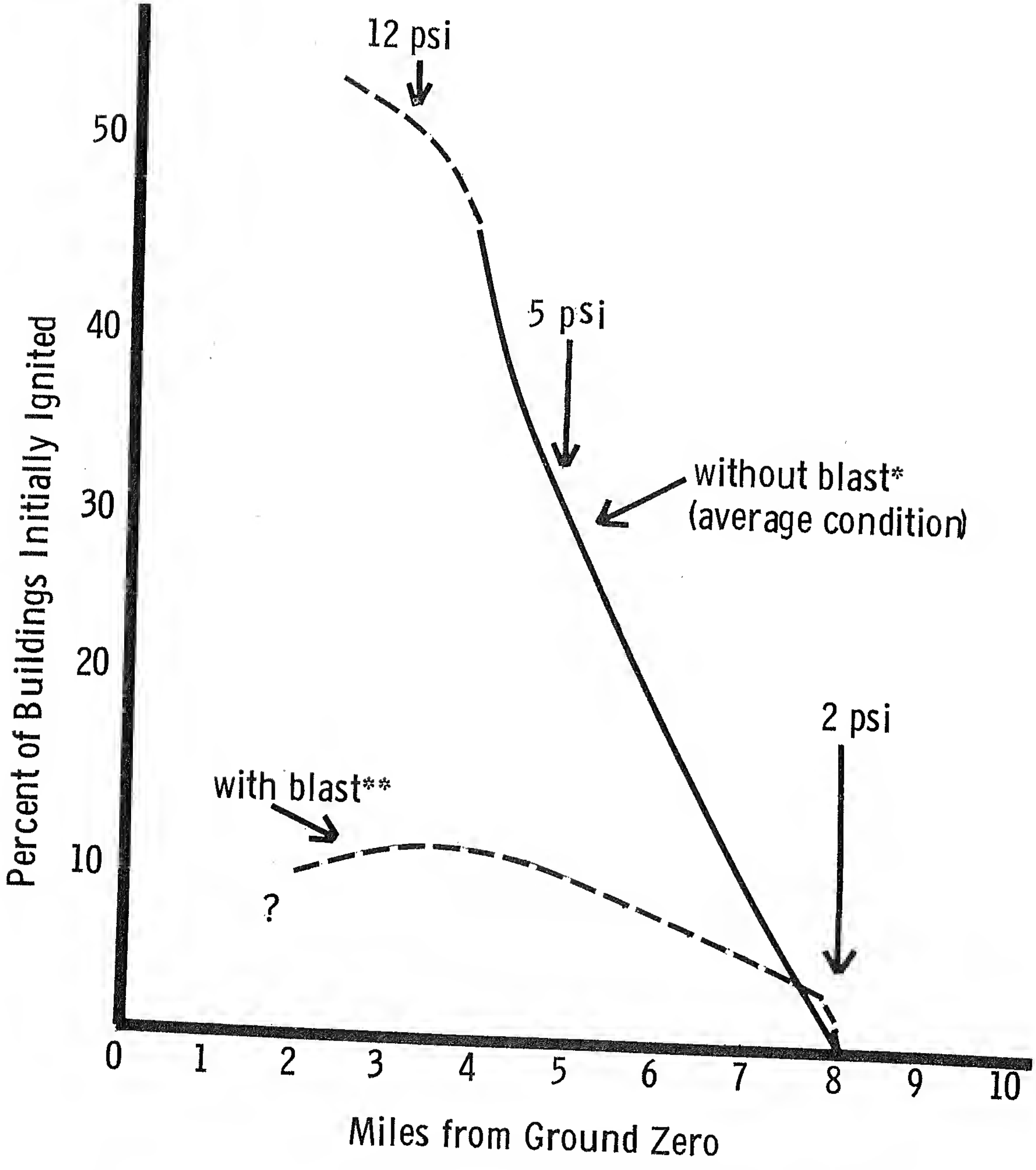
COMMON KINDLING FUELS

	WEAPON YIELD (MT)		
	1	5	25
	(calories per square centimeter)		
GROUP I			
Crumpled newspaper, dark picture area	7	9	15
Black lightweight cotton curtains	6	8	11
Dry rotted wood and dry leaves	6	7	10
GROUP II			
Beige lightweight cotton curtains	32	42	55
Kraft corrugated paper carton	19	22	32
White typing paper	30	42	60
Heavy dark cotton drapes	22	27	50
GROUP III			
Upholstered Furniture	28	40	56
Beds	22	34	52

RELATIONSHIP OF BLAST AND HEAT
(Surface Burst on a Clear Day)

BLAST OVERPRESSURE (psi)	HEAT RADIATION (cal. /sq. cm.) 1 MT	5 MT	25 MT
1	6	4	2.5
2	21	18	14
5	100	100	105
12	350	440	620
20	560	900	1500

INITIAL FIRES FROM A 5-MT SURFACE BURST IN DETROIT



*From Takata and Salzberg, **Development and Application of a Complete Fire Spread Model**, IITRI, June 1963, AD 684 874.

Based on Miller, R.K., et al., **Analysis of Four Models of the Nuclear-Caused Ignitions and Early Fires in Urban Areas, The Dikewood Corporation, August 1970, AD 716 807.

CASUALTIES IN LARGE FIRES

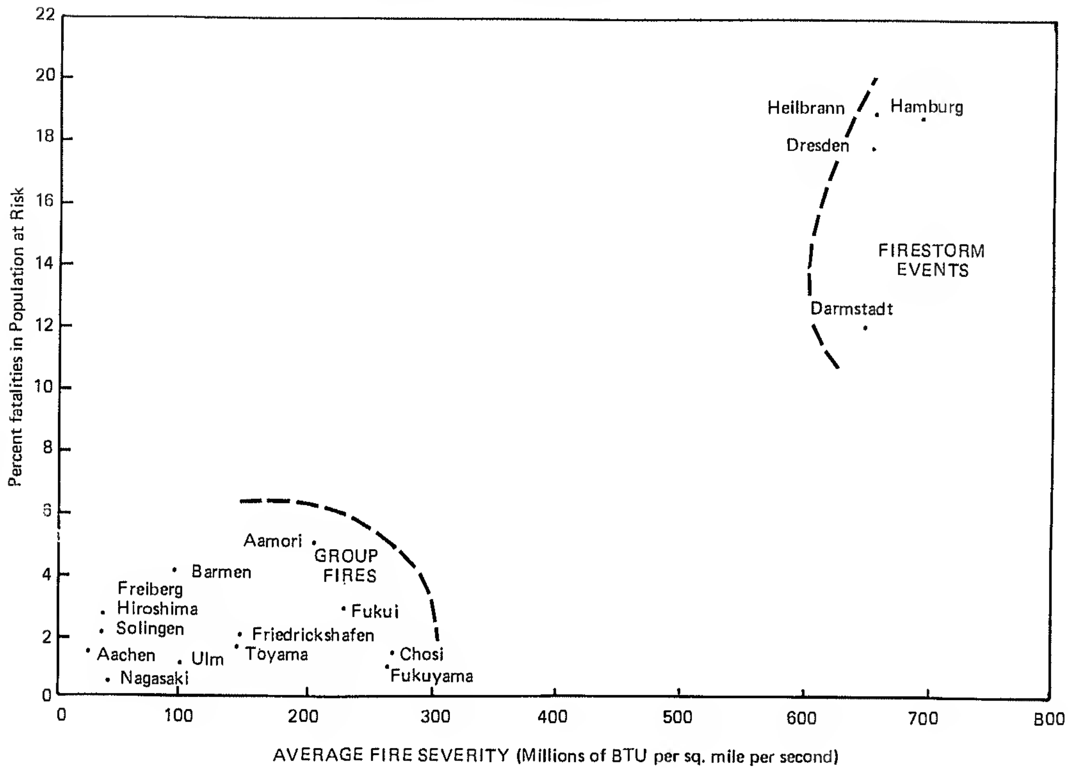
Loss of life in the large fires of World War II was considerable. The term "firestorm," coined by a German journalist, dramatically expressed the awesome nature of some of these mass fires. It took little imagination to transfer the worst of these occurrences to the event of nuclear attack. Numerous writers were led to postulate great areas of fire in which survival was unthinkable.

To gain a more objective understanding of the fire threat, DCPA has sponsored a number of studies of World War II fire experience in considerable detail. One of the results of this analysis is shown here. The loss of life among the population at risk for a large number of war fires was found to be related to the fire severity. The severity of a large fire was expressed in terms of the average heat output as measured in millions of BTU per square mile of fire area per second. [A BTU (British Thermal Unit) is similar to a calorie, being the amount of heat necessary to raise the temperature of a pound of water 1 degree Fahrenheit. A BTU is equal to 252 calories.]

Note that a large number of wartime fires are classed as "group fires." The fire severity ranged up to about 300 million BTU per square mile per second and the loss of life ranged up to 5 percent of the population at risk. Note also that the fires caused by the nuclear detonations at Hiroshima and Nagasaki are among the least severe.

At the other end of the chart are a relatively few war fires labeled "firestorm events." These cases generated a fire severity between 600 and 700 million BTU per square mile per second. The corresponding loss of life ranged between 12 and 20 percent of the population at risk. All of these "firestorms" occurred in German cities.

FATALITIES IN WORLD WAR II FIRES*



*Lommasson and Keller, **A Macroscopic View of Fire Phenomenology and Mortality Predictions**, Dikewood Corporation, DC-TN-1058-1, December 1966.

FIRESTORM POSSIBILITIES

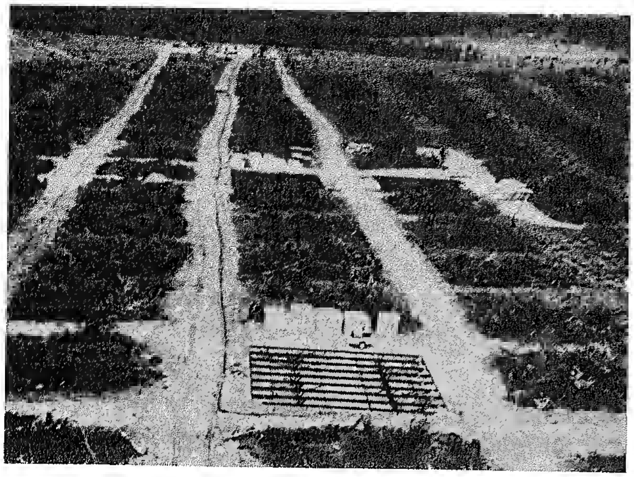
The marked increase in loss of life found in "firestorm events" focused early attention on the nature of these fires and the necessary conditions for their occurrence. The fire research community is not entirely agreed on what constitutes a firestorm, except in broad qualitative terms. What is generally meant is a mass fire characterized by high-velocity inrushing winds, a well-developed convection or smoke column reaching high into the atmosphere, and little spread beyond the area that contained the initial fires. It has been considered significant that the only clear-cut firestorm events in World War II occurred in German cities, of which the Hamburg fire was the most extreme and the most studied.

Research has been done relating fire-induced inrush wind velocities to the energy release rate of these large fires. In Germany, velocities of 50 miles per hour or greater were associated with firestorms. Winds of 40 mph or less were associated with group fires. Peak fire-induced winds at Hiroshima were estimated to reach 35 mph, which places it well down in the group fire category.

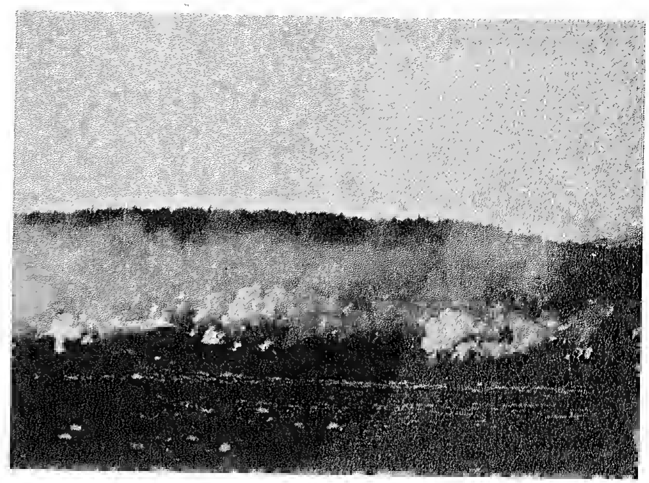
Group fires burn outward with spread from the initial fires determined by the closeness of buildings and the wind conditions prevailing at the time. Firestorms apparently involve rapid spread within the firestorm area to initially unignited structures, aided most probably by the high inrush winds. This one hundred percent involvement in firestorms is confirmed by observer reports.

From 1963 to 1967, OCD participated jointly with the U.S. Forest Service and the Defense Nuclear Agency in a series of mass fire experiments called Operation FLAMBEAU. Slash timber was piled in large arrays representing houses and burned to measure the resulting fire environment. The left-hand picture shows the largest array, occupying 40 acres, before the burn. The right-hand picture shows the array at the height of the burn. Through these tests and other work, it was confirmed that the energy release from a large fire depended on the amount of fuel available, the burning rate of the individual buildings, and the weather conditions at the time of the fire. The table indicates the conditions thought necessary for production of a firestorm.

Since we now estimate that only about 10 percent of the buildings will be ignited by a nuclear detonation, one of the criteria for firestorm conditions, that at least 50 percent be on fire initially, is not met. In other words, present evidence suggests that the most severe nuclear fire situation will be similar to that which occurred in Hiroshima. The information in the next few panels confirms this view.



Flambeau plot before burning



Flambeau plot during burning

CRITERIA FOR PREDICTING FIRESTORMS*

- Greater than 8 pounds of fuel per square foot of fire area.
- Greater than 50 percent of structures on fire initially.
- Surface wind less than 8 miles per hour initially.
- Fire area greater than 0.5 square mile.

*Rodden, R.M., et al, **Exploratory Analysis of Fire Storms**, Stanford Research Institute, 1965, AD 616 638.

FUEL LOADING AND BUILTUPNESS

The total amount of combustibles in a building, including both structure and contents, has an important bearing on the potential severity of fires. Each pound of combustibles typically generates about 8000 BTU upon burning.

An estimated range of fuel loadings in typical building uses or "occupancies" is shown here. Whether a particular structure would have a fuel loading near the high or low end of the range shown depends mainly on the type of construction of the building. For example, the typical combustible contents of residences averages about 3.5 pounds per square foot of floor area, so a total fuel loading near 20 would indicate a home constructed largely of wood whereas a fuel loading of 10 pounds per square foot would be appropriate to brick or other masonry construction.

Similarly, the combustible contents of office and commercial space ranges from 7 to 10 pounds per square foot of floor area. Combustible contents of industrial and storage buildings vary quite widely depending on the nature of the operations involved.

Another important factor in fire growth and spread is the density of construction. This factor is called "building density" or "builtupness" and is expressed usually as the fraction of the total area, including streets, parks, and the like, that is under roof. Typically, the building density in residential tracts ranges from about 10 to 25 percent; that in commercial and downtown areas up to 40 percent. Industrial and storage areas can vary widely in building density. Those with very high density are often referred to as "massive industrial" areas.

The combination of builtupness and fuel loading per square foot of building gives the fuel loading per square foot of fire area. The firestorm area at Hamburg was about 45 percent builtup with buildings having a fuel loading of about 70 pounds per square foot. This would mean about 32 pounds of fuel per square foot of fire area, four times the 8 pounds per square foot estimated as the minimum necessary for firestorm conditions.

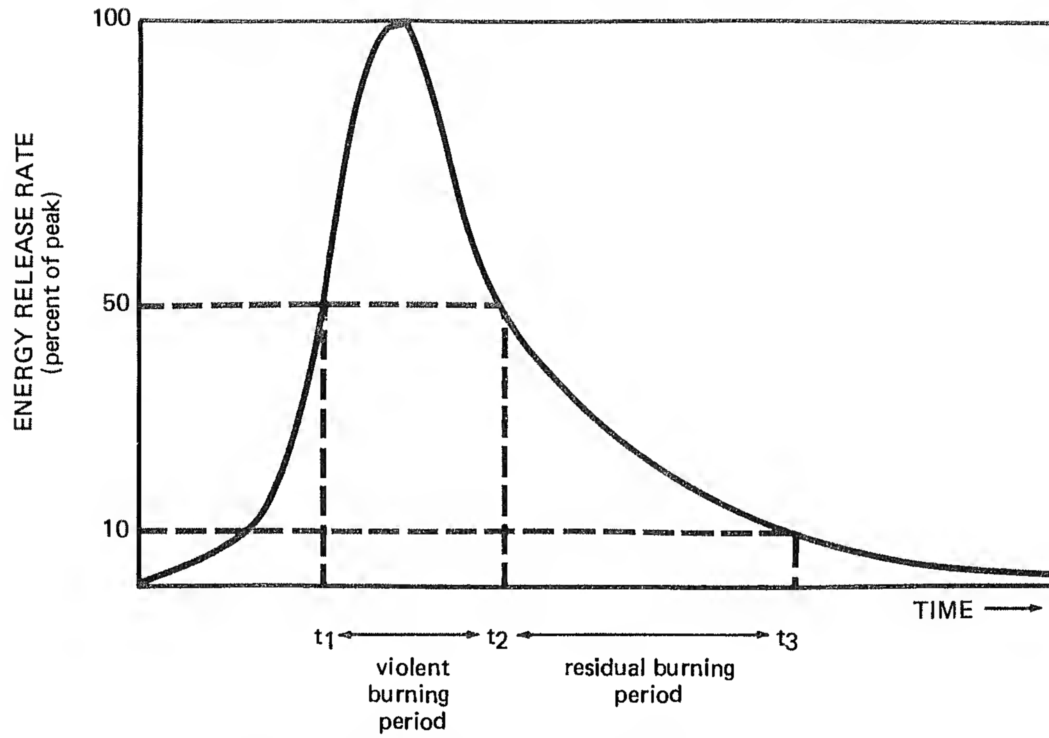
In contrast, a residential area 10 percent builtup with single-story wood-frame detached homes would have a fuel loading of only 2 pounds per square foot, well below the criterion.

ESTIMATED RANGE OF FUEL LOADINGS

OCCUPANCY	FUEL LOAD PER STORY* (pounds per square foot)
Hi-Rise Residential (Fire Resistive)	3 - 5
Brick or Frame Residential	10 - 20
Office and Commercial	10 - 40
Industrial	0 - 30
Storage	20 - 80

*Includes building structure and contents.

ESTIMATES OF BURNING TIMES



BURNING TIMES FOR URBAN STRUCTURES*

CONSTRUCTION TYPE	VIOLENT BURNING TIME (min.)	VIOLENT BURNING ENERGY RELEASE (percent)	RESIDUAL BURNING TIME (min.)	RESIDUAL BURNING ENERGY RELEASE (percent)
Light Residential	10	80	12	20
Heavy Residential	13	70	20	30
Commercial	25	60	60	40
City Center and Massive Manufacturing	55	30	120	70

*From Chandler, et al., **Prediction of Fire Spread Following Nuclear Explosions**, Pacific Southwest Forest and Range Experiment Station, U.S. Forest Service, 1963.

FIRE SEVERITY

We have now covered the chief factors involved in estimates of fire severity in nuclear attack. These are: (1) the fuel loading in individual buildings, (2) the builtupness or building density of the area, (3) the burning rate of buildings, and (4) the proportion of buildings burning at the same time. It will be useful to summarize what this information means.

We have already mentioned that, in the Hamburg "firestorm" area, there was a fuel loading of about 32 pounds of fuel per square foot of fire area. Using the heat value of combustibles as about 8000 BTU per pound, and a burning time of 2 hours and 55 minutes for buildings in city centers, we can calculate an average energy release rate, or "power density" as the fire research community prefers to call it, of about 685 million BTU per square mile per second—which is not far from the estimate in the World War II fire casualty chart shown in Panel 10.

At Hamburg, at least 50 percent of the structures were initially set on fire and the burning period was so long that the others also were burning at the same time as those initially on fire. The upper calculation shown here assumes this.

Now, take another example—2-story brick residences, perhaps many row houses, so that the area is 25 percent built-up. As we have seen, such houses might have about 10 pounds of fuel per square foot per story or 20 pounds per square foot for 2-story buildings. At 25 percent builtupness, this would be 5 pounds of fuel per square foot of fire area, less than the "magic number" of 8 pounds previously given as the threshold for possible firestorm events. Using a burning period of 33 minutes (1980 seconds) for "heavy residential" construction and 10 percent of the buildings burning simultaneously, we obtain a fire severity of about 56 million BTU per square mile per second, somewhat higher than that estimated for Hiroshima. In Japan, the burning time of most buildings was short, since there was a great deal of light construction. Only a portion of buildings were burning at the same time, and hence, firestorms did not result. This appears to be the situation in American cities as well and perhaps is the case for all nuclear detonations.

Fire defense can be planned for the fire environment expected in nuclear attack. What measures will be effective can be determined from the details of fire growth and spread described in the next series of panels.

SOME TRIAL CALCULATIONS

The Hamburg Case:

Fire Severity - 8000 BTU per pound of fuel times 32 pounds of fuel per square foot of fire area times 28 million square feet per square mile divided by 10,500 seconds burning time for "city center and massive manufacturing" areas

or

Fire Severity = about 685 million BTU per square mile per second average rate of energy release.

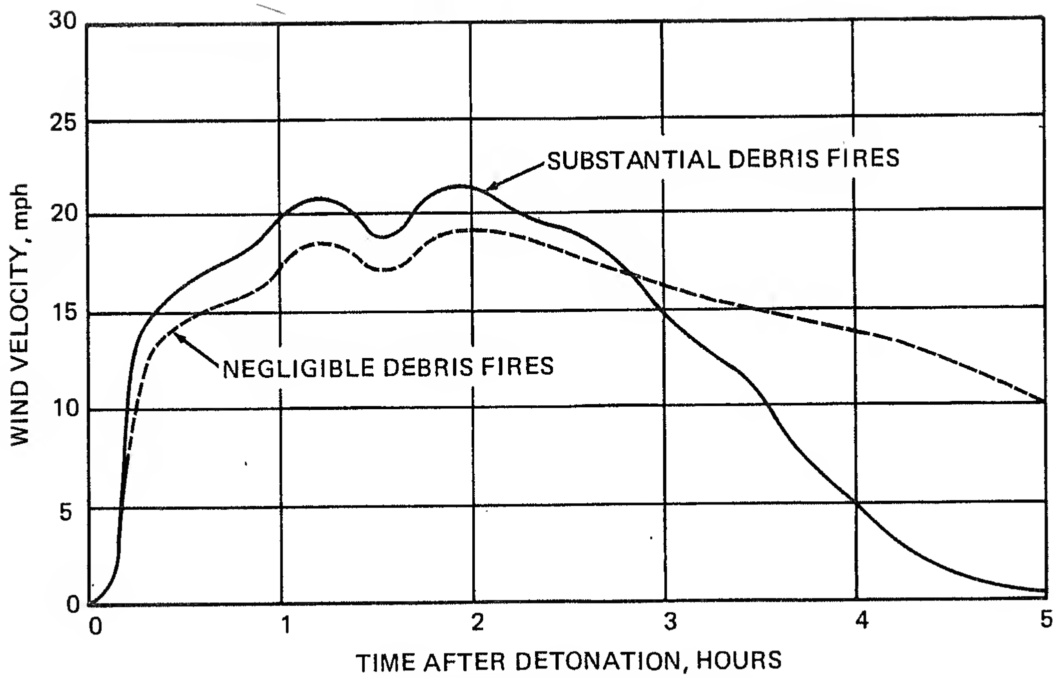
Heavy Residential Case in Nuclear Attack

Fire Severity - 8000 BTU per pound of fuel times 10 pounds of fuel per square foot per story in brick buildings times 2 stories average building height times 0.25 fraction of the area covered by buildings times 28 million square feet per square mile divided by 1980 seconds burning time in "heavy residential" construction times 1/10 of the buildings burning at one time,

or

Fire Severity = about 56 million BTU per square mile per second average rate of energy release.

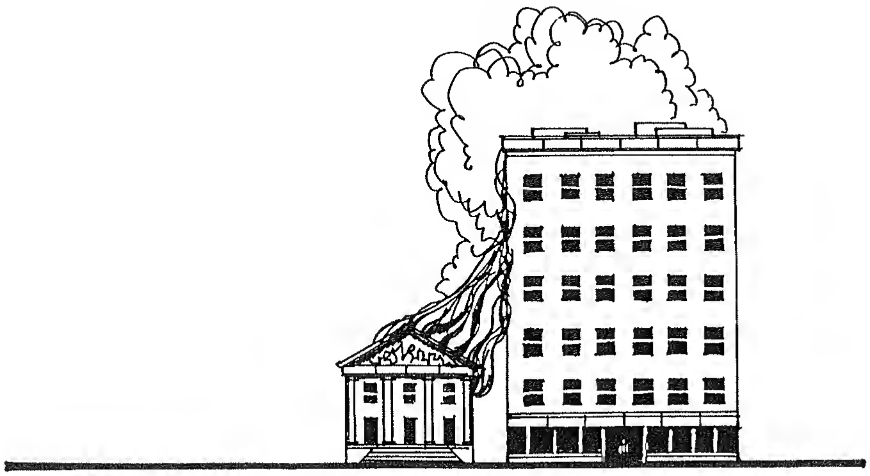
DOWNTOWN CHICAGO



ESTIMATED FIRE WINDS IN CHICAGO LOOP*
(from 5-MT surface burst at 5 miles)

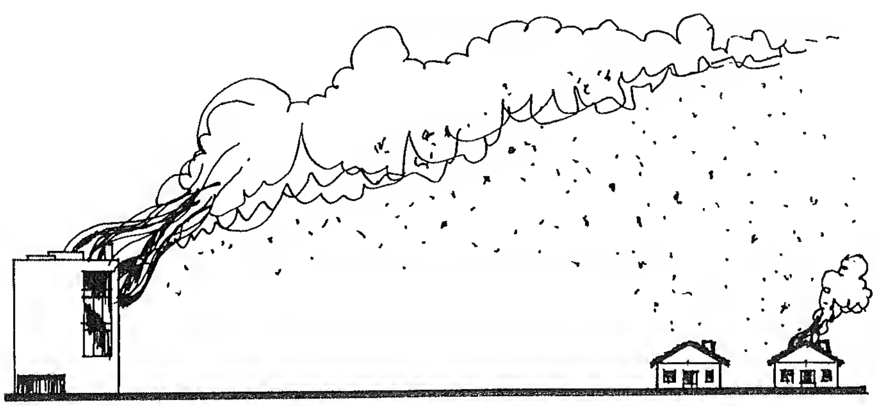
*From Takata, A.N. **Fire Spread in High Density High-Rise Buildings**, IITRI, February 1971, AD 719 731.

FIRE SPREAD BETWEEN BUILDINGS



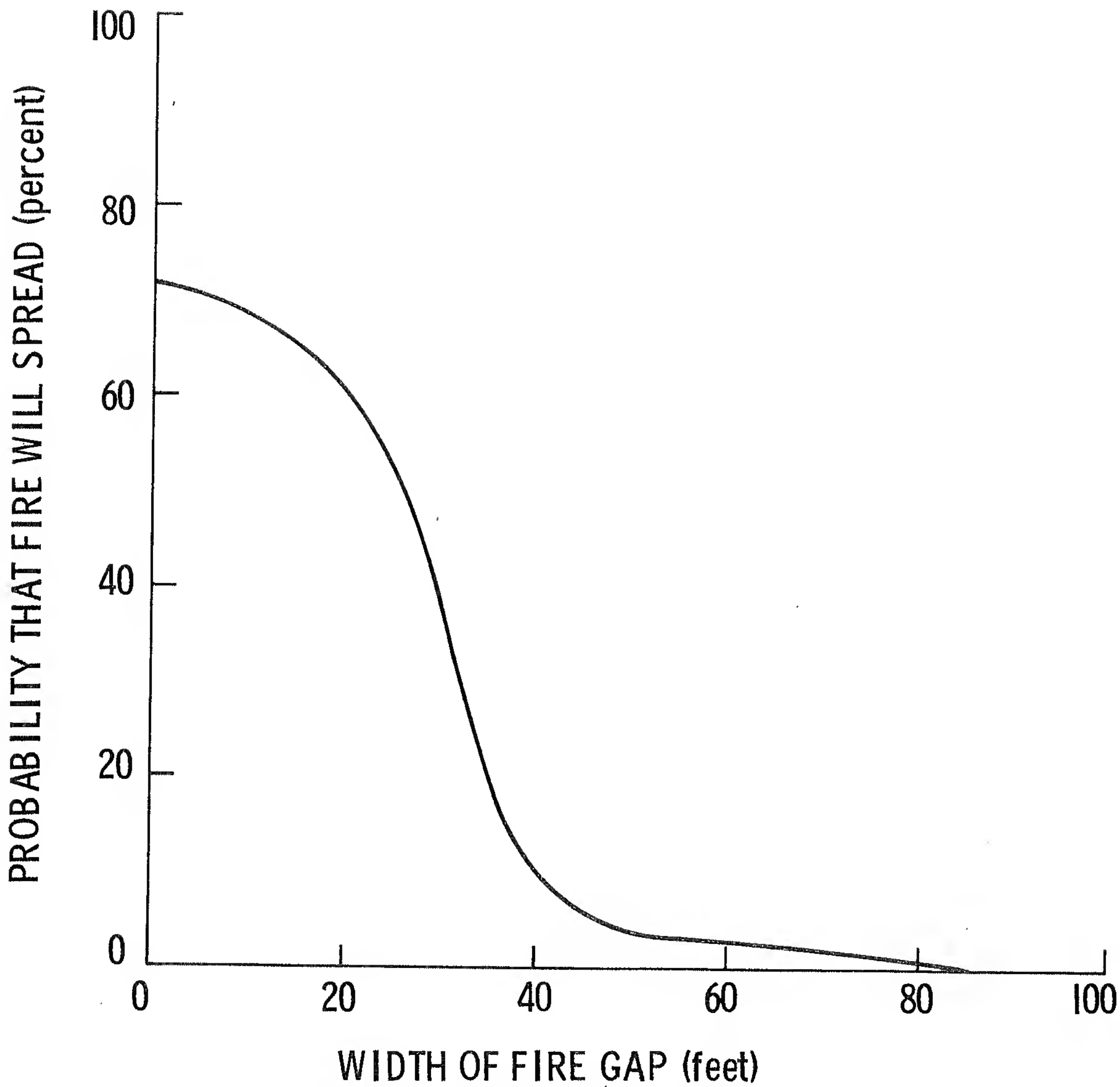
FIRE SPREAD BY CONVECTION

FIRE SPREAD BY RADIATION



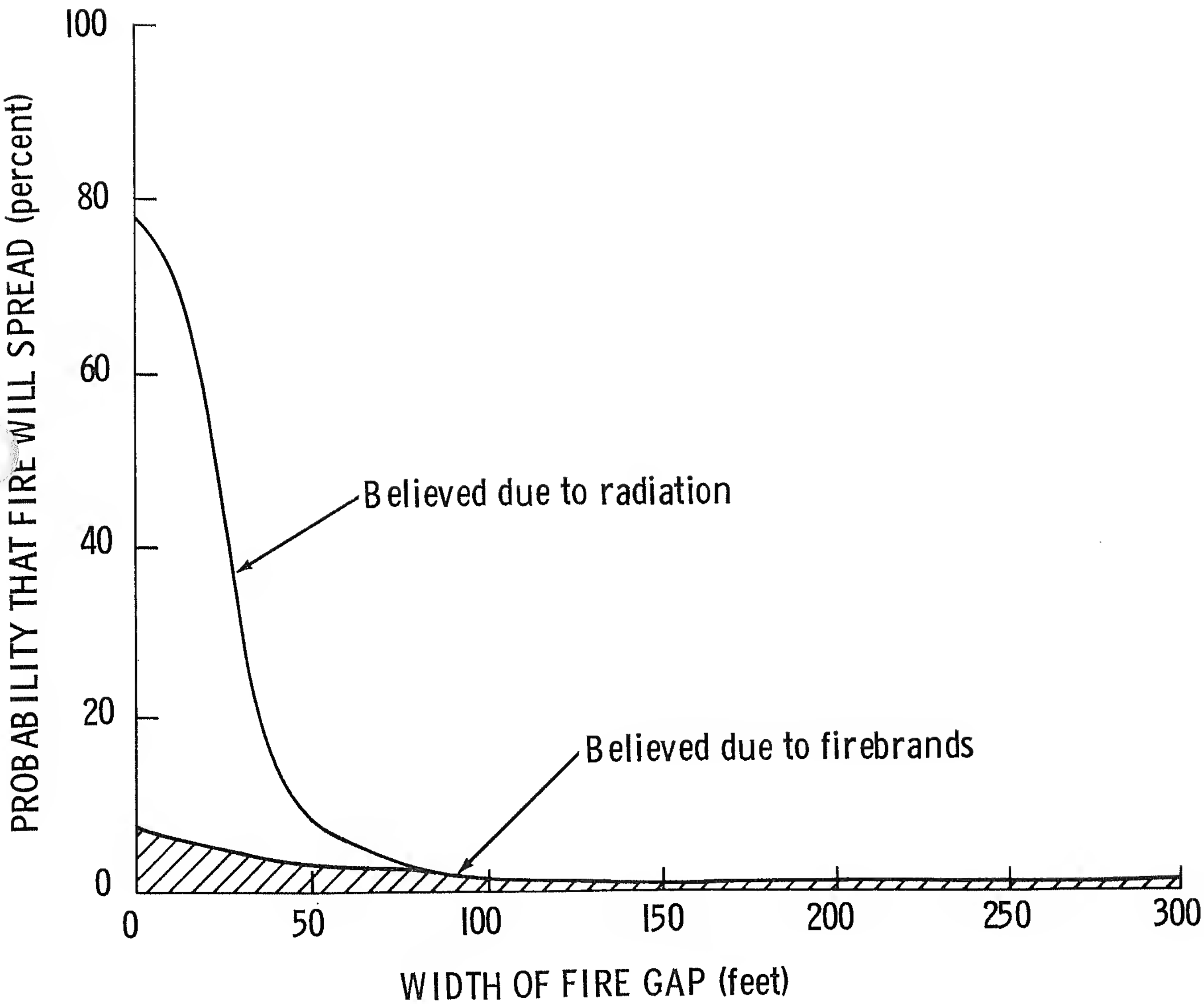
FIRE SPREAD BY FIREBRANDS

FIRE SPREAD IN THE DARMSTADT FIRE*



*From Takata and Salzberg, **Development and Application of a Complete Fire-Spread Model**, IITRI, June 1968, AD 684 874.

FIRE SPREAD AT HIROSHIMA*



*From Takata and Salzberg, **Development and Application of a Complete Fire-Spread Model**, IITRI, June 1968, AD 684 874.

THE DIMENSIONS OF FIRE SPREAD

To illustrate the overriding importance of fire spread, let us use the example of the 5-MT surface burst at the location shown on the previous panel. For the moment, we will ignore two important factors: (1) the effect of the blast wave on fire ignitions, and (2) the effect of any fire countermeasures, either before the attack or after the fires are started.

For this example, we will assume that all buildings experiencing at least 6 psi blast overpressure are destroyed at the outset. Since most of the buildings with the blast circle shown on Panel 23 are residential or industrial buildings, this assumption is not unrealistic. These immediately destroyed buildings comprise about 14.5 percent of all the buildings in the Detroit area shown on the tract map. Outside the 6-psi line, an additional 3.76 percent of all the buildings are initially ignited.

As can be seen in the table, although less than 4 percent of the undestroyed buildings are initially ignited by the fireball, almost half of the buildings are eventually burned. Together with the nearly 15 percent assumed to be destroyed by blast, almost two-thirds of all buildings are lost by the end of the first day. At 28 hours after detonation, about 1 percent of all buildings are still burning around the periphery of the damaged area, so the destruction shown in the table is not the complete story.

The loss of property due to fire spread dominates the picture, even though a "fire storm" never occurs. Spread by radiation from nearby burning buildings appears to be the most prevalent mechanism, but one should not lose sight of the fact that most of the losses outside the area of high initial ignitions were originated by the firebrands.

We do not know how accurate this picture of the fire spread is, except that it probably represents the upper limit of what might occur without any fire defenses. The reason that it may represent an upper limit is that the effects of the blast wave, ignored here, will generally reduce initial ignitions and may impede fire spread. The main thing that blast effects will provide is additional time to control the fire situation, for even if the initial ignitions do not exceed 10 percent throughout the blast area, these fires can eventually spread as shown here. Thus, if control is not successful in the first few hours, new fires may be set for days following the attack.

Finally, a major implication for operational planning is that mutual aid from nearby localities will have time to play an important role in fire defense.

FIRE SPREAD HISTORY IN DETROIT
(Percent of all buildings ignited and burned*)

TIME (hours)	IGNITED BY FIREBALL	IGNITED BY RADIATION	IGNITED BY FIREBRANDS	TOTAL BURN
0	3.76	—	—	3.76
1	3.76	2.78	—	6.54
3	3.76	8.93	5.50	18.19
10	3.76	17.55	11.50	32.81
28	3.76	28.01	18.16	49.93

* In addition, 14.46 percent of all buildings destroyed by blast, for a total destroyed and burned of 64.39 percent.

From Takata and Salzberg, **Development and Application of a Complete Fire-Spread Model**, Vol. II, IITRI, June 1968, AD 684 874.

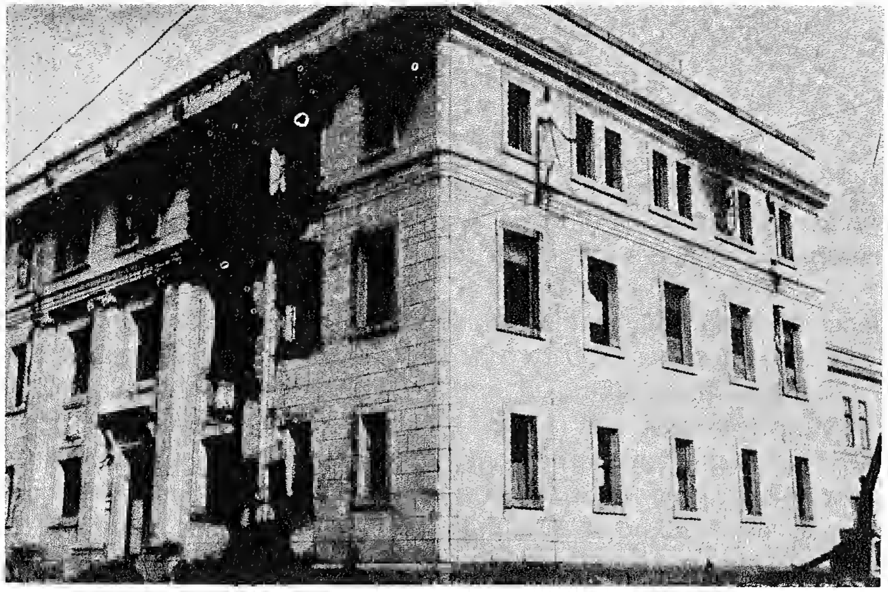
SOME JAPANESE EXPERIENCES

One might question at this point whether it is reasonable to assume that the survivors in a "low-risk" shelter facility can suppress ignitions and fires in an area damaged by a nuclear detonation. The most nearly parallel situation and, hence, best evidence comes from the nuclear attack on Hiroshima at the close of World War II. All of the evidence we have cited in this chapter suggests that the fire situation we must expect would be similar to that experienced at Hiroshima.

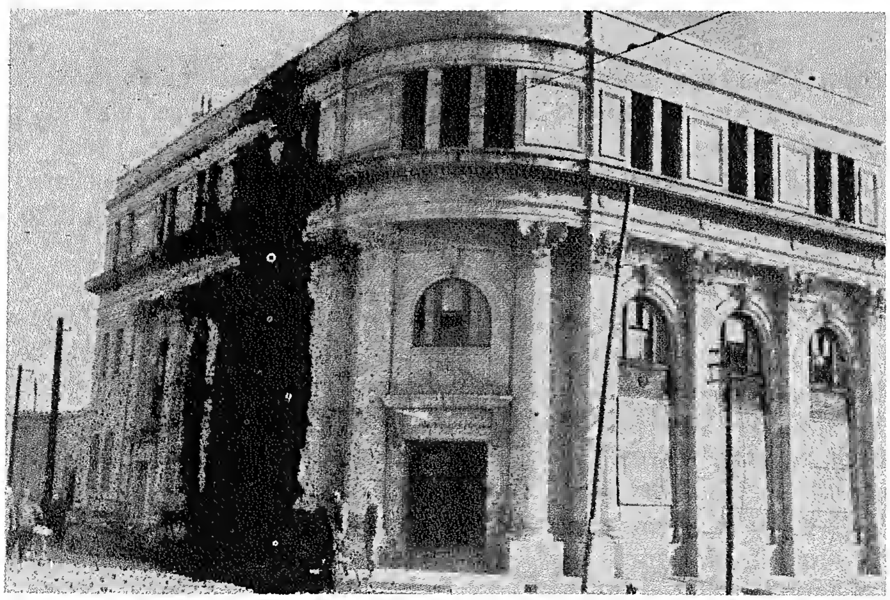
The upper photograph shows the Hiroshima branch of the Bank of Japan, a 3-story reinforced-concrete frame building of earthquake-resistant design. This building was only 1300 feet from ground zero, where an overpressure of about 18 psi occurred. About 100 people were in the bank at the time, of which about half were killed. Only four of the survivors are said to have been uninjured. Whether because the detonation was high above the building, whether because there were metal shutters at the windows, or whether because of effects of the blast wave, no initial ignitions occurred. About 1-½ hours afterward, a fire started in a room on the second floor from a firebrand. The nearest burning building was only 25 feet distant but the brand was said to come from nearby burning trees on another side. The survivors extinguished the blaze with water buckets, preventing further damage. A little later, a fire was started on the third floor. It was beyond control when discovered and the third floor burned out. But the fire did not spread to the lower floors.

The lower photograph shows another bank building, farther away, that experienced about 8 psi blast overpressure. Again, no initial ignitions were reported. However, at about 10:30 A.M., over 2 hours after the detonation, firebrands from the south exposure ignited a few pieces of furniture and curtains on the first and third stories. The fires were extinguished with water buckets by the building occupants. Negligible fire damage resulted.

These are but two of several examples of successful fire defense taken from the U.S. Strategic Bombing Survey report of events at Hiroshima. If one assumes that Americans can do what the unsuspecting residents of Hiroshima did, self-help measures by shelter fire-guard teams would appear to be effective.



BANK OF JAPAN BUILDING AFTER ATTACK ON HIROSHIMA



GEIBI BANK CO. BUILDING AFTER ATTACK ON HIROSHIMA

LIFE HAZARDS IN STREETS

Another question is whether it is reasonable to assume that occupants of a threatened high-risk shelter facility can move to a nearby low-risk facility through the damage caused by a nuclear detonation. There is some basis for an answer to this question.

The evidence from Hiroshima indicates that blast survivors, both injured and uninjured, in buildings later consumed by fire were generally able to move to safe areas following the explosion. Of 130 major buildings studied by the U.S. Strategic Bombing Survey (these were hospitals, churches, commercial, and industrial buildings, not the smaller wooden Japanese residences), 107 were ultimately burned out, in total or in part. Of those suffering fire, about 20 percent were burning within the first half hour. The remainder were consumed by fire spread, some as late as 15 hours after the blast. This situation is not unlike the one our computer-based fire spread model described for Detroit (Panel 24).

We have also seen, in Chapter 2, that, except in densely builtup areas of multistory buildings, debris depths will average only a foot or so. This debris would immobilize wheeled vehicles but not pedestrian traffic.

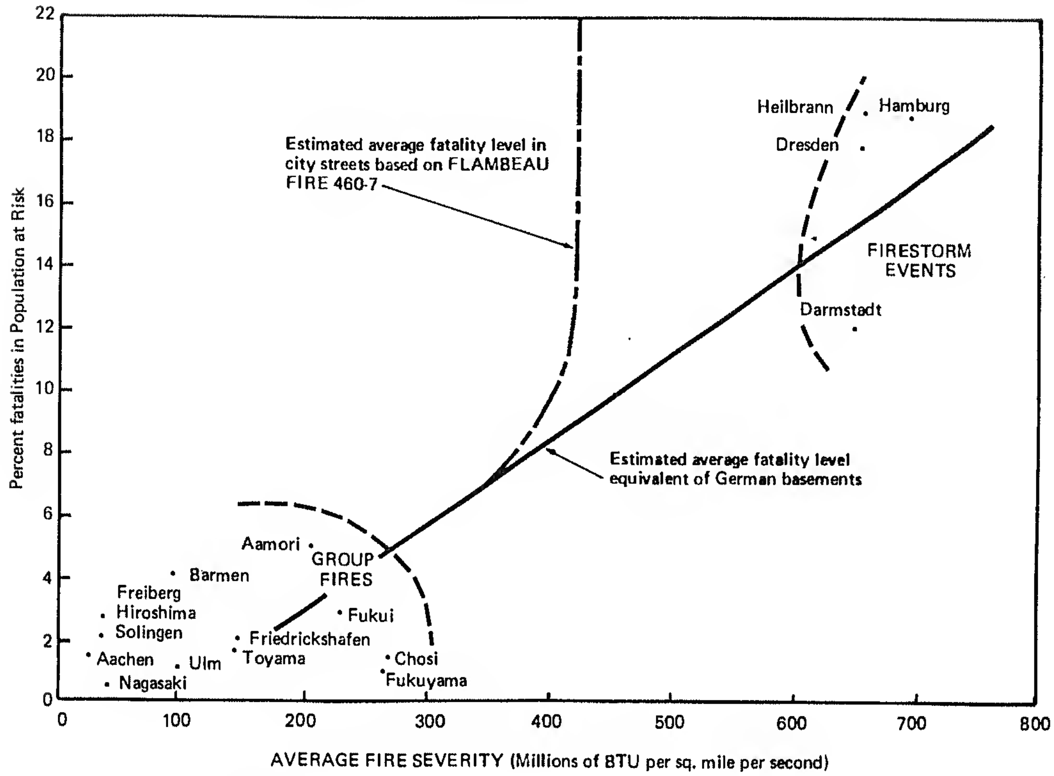
Measurements have been made at the Operation FLAMBEAU mass fire experiments of the hazards to life safety in the streets. It was found that lack of oxygen was not a problem. (Indeed, flames will die out before the air gets too thin for breathing.) Nor was carbon dioxide, a combustion product, found to present a hazard. Heat radiation, elevated air temperatures, carbon monoxide, and lack of visibility due to smoke were found to present a serious threat to life.

The upper chart shows the World War II fatality chart we have seen before, with a line added to show the average fire severity at which mortality in the streets would be expected to become total, based on FLAMBEAU measurements. The table below shows the time period during one of the FLAMBEAU fires when the hazard threshold was exceeded. These fires were intense and the "streets" were only 25 feet wide. Nonetheless, the evidence suggests that there will be situations when people in the streets would be in great peril. These situations will be those in which congested areas with narrow streets are burning violently. The implications for planning are:

(1) Areas where intense conflagrations could occur should be identified in the fire defense plan, and

(2) Decisions to evacuate survivors from these potential conflagration areas should be made as soon as uncontrolled fires are observed, to allow the maximum escape time before radiation intensities, air temperatures, carbon monoxide, and limited street visibility build up to lethal levels.

FATALITIES IN WORLD WAR II FIRES*



* Lommasson and Keller, DC-TN-1058-1, December 1966

HAZARD PERIODS DURING FLAMBEAU 760-12*

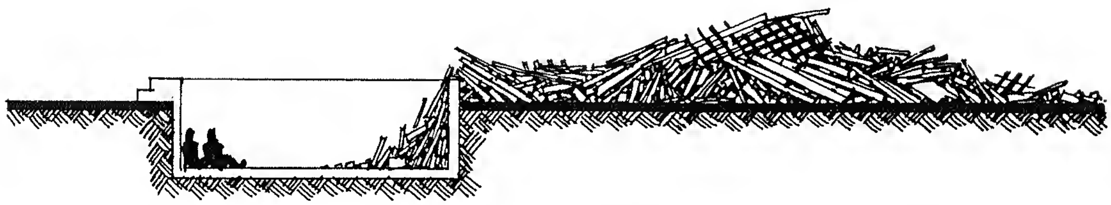
HEAT RADIATION	Over 3 Hours
AIR TEMPERATURE	90 Minutes
CARBON MONOXIDE	80 Minutes
STREET VISIBILITY**	60 Minutes

From Butler, C.P., **Operation Flambeau, Civil Defense Experiment and Support,** USNRDL, June 1968, AD 682 476.

** In addition, smoke conditions causing severe eye pain persisted for about 6 hours.

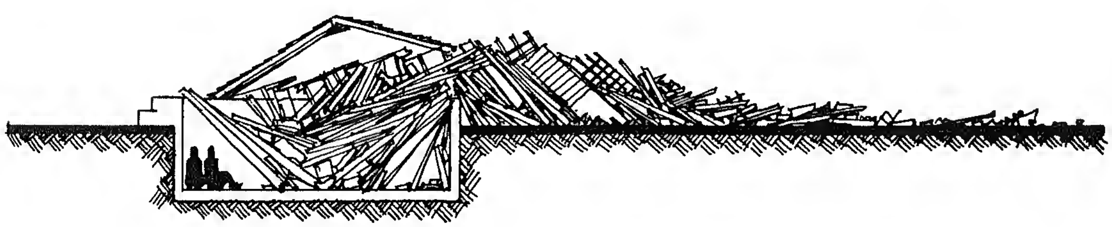
FIRE HAZARDS IN RESIDENTIAL BASEMENTS

over 5 psi



SITUATION OF LEAST FIRE RISK

2 - 5 psi



SITUATION OF GREATEST FIRE RISK

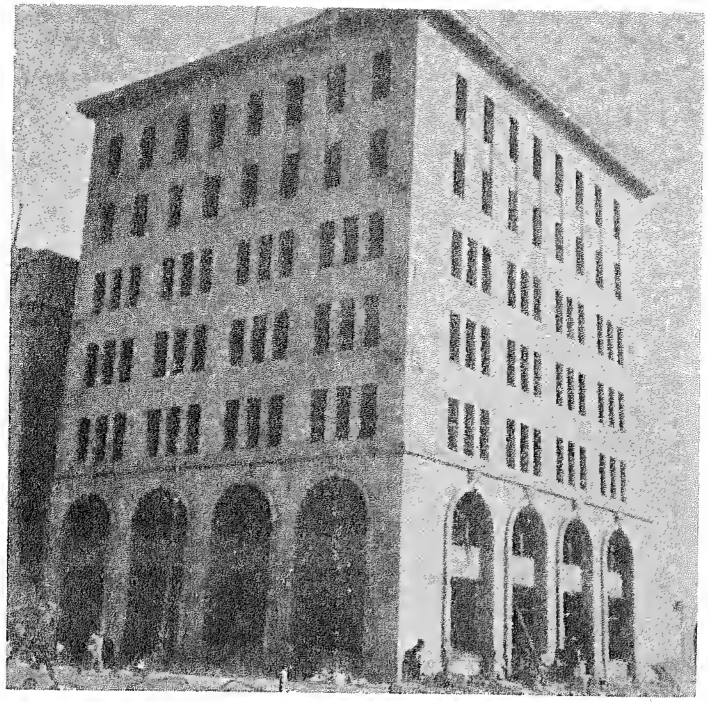
FIRE RISK IN LARGE BASEMENTS

Shelters in the basements of large buildings, particularly those described as "good shelters" in Chapter 2, offer a substantial degree of protection against fire. An example from Hiroshima, the Fukoku Building, is shown in the upper photograph. This seven-story reinforced-concrete frame building was near the Bank of Japan building and experienced about 20 psi blast overpressure. Subsequently, the building was gutted by fire. Three panels of the ground floor were depressed by the blast but fire did not penetrate into the basement of the building. This failure of the fire to involve the basement was a common occurrence at Hiroshima.

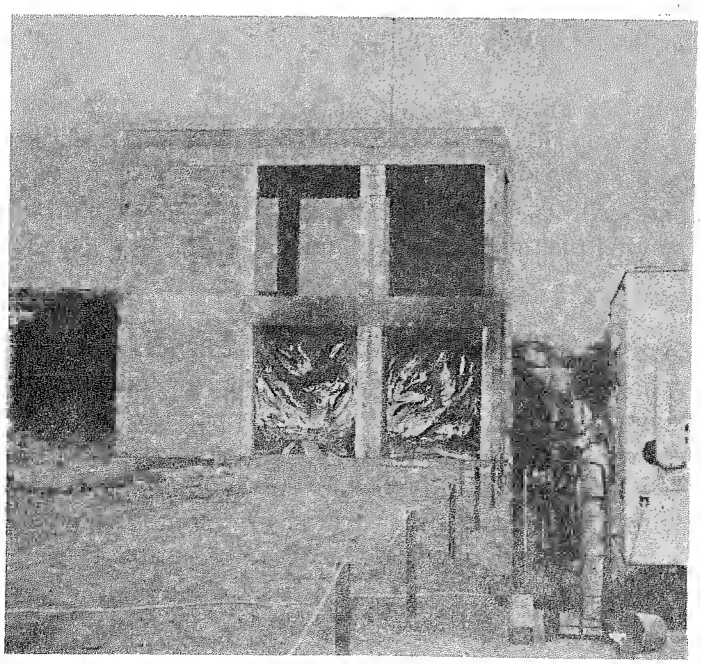
Since the Hiroshima basements were not occupied as shelters, no evidence exists as to whether heat and noxious gases would have prevented survival inside them. There were numerous instances of loss of life in German basements during the "firestorms," mainly due to excessive heat and carbon monoxide poisoning. On the other hand, the majority of basement occupants in these areas survived. To gain a better understanding of the life hazard in basements, experiments have been conducted for the past several years in a reusable building located in Gary, Indiana. This fire-test facility, shown in the lower photograph, has two stories and a basement. The walls are designed to permit openings to simulate varying degrees of blast damage. Combustibles can be placed in one or both stories to represent the room contents for various occupancies—residential, office, commercial, library, and the like. The ground floor slab can be adjusted in thickness and in tightness to simulate openings that might exist.

Experiments to date indicate toxic gases from most debris fires will not penetrate a ventilated shelter sufficiently to cause a substantial hazard. Heat transmitted through the floor slab can present a serious problem, however. For a slab 5 inches thick, which is a common thickness over basements offering "good" blast protection, the heating reaches an equivalent of four added occupants for every shelter space, given a residential fire loading above. The added heat load would make the basements untenable in a matter of an hour or so. An important finding has been that as little as one-third gallon of water per square foot of floor area applied in the first half hour after the start of a fire on the ground floor will reduce the heating effect to about one-quarter of what it would otherwise be. Since broken water piping in the above-ground part of a large building might very well provide such cooling, basements might remain tenable for considerably longer periods than one hour.

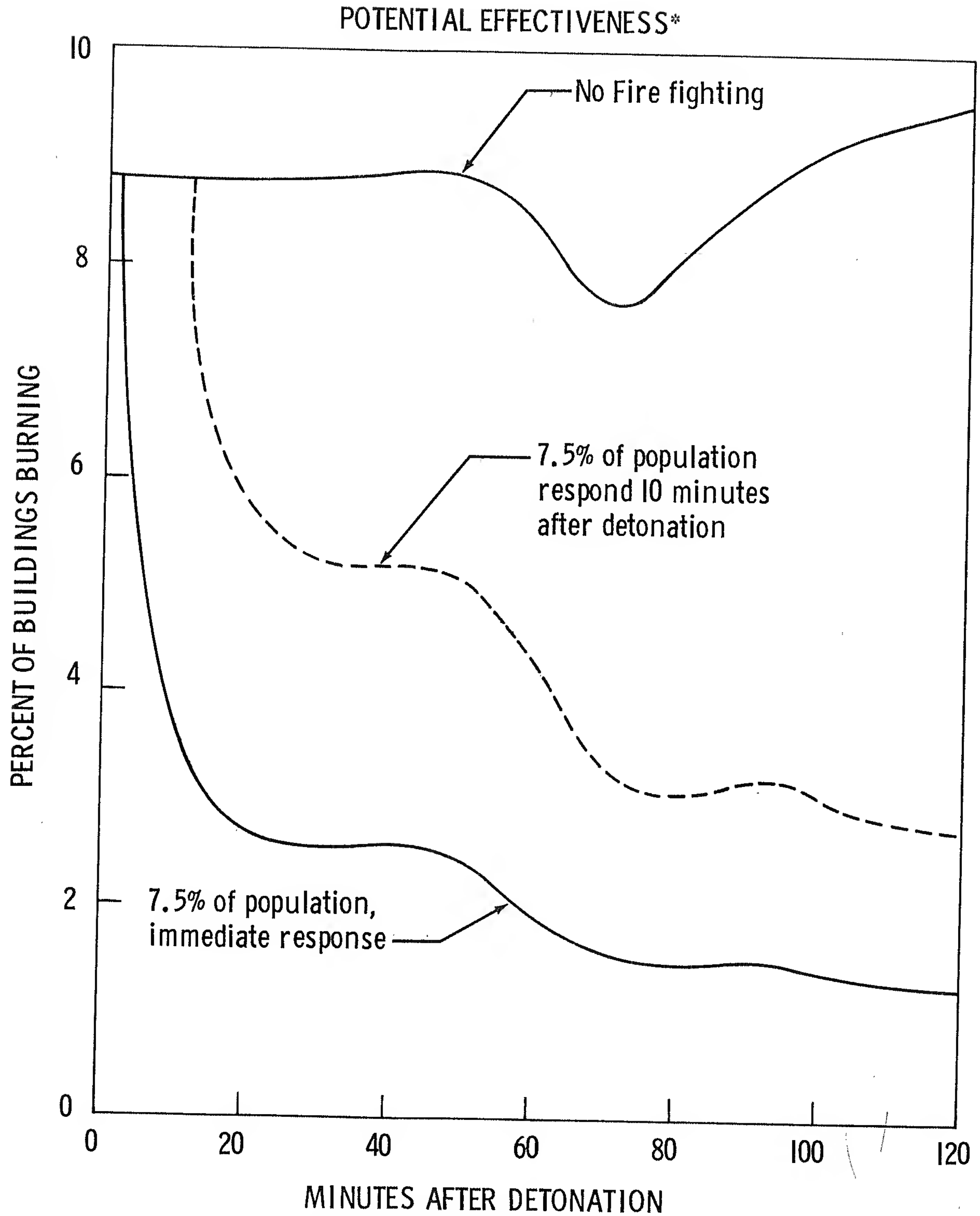
Nonetheless, the potential threat of debris fires on the floor above the basement should be guarded against. In addition to possible preattack measures to reduce the fire loading there, "fire guard" teams should be planned for each shelter facility so that incipient fires can be promptly suppressed.



FUKOKU BUILDING FOLLOWING THE HIROSHIMA ATTACK AND FIRE



FIRE ABOVE BASEMENT IN GARY FIRE TEST FACILITY



*From Takata, A.N., **Mathematical Modeling of Fire Detenses**, IITRI, March 1970, AD 705 388.

SUGGESTED ADDITIONAL READING

Bond, Horatio (editor), **Fire and the Air War**, National Fire Protection Association, Boston, Mass., 1946.

Fristrom, Robert M., (editor), **Fire Research Abstracts and Reviews**, National Academy of Sciences, Washington, D.C. (published three times a year).

Tryon, George H., (editor), **Fire Protection Handbook**, National Fire Protection Assoc., Boston, Mass. (latest edition).

Committee on Fire Research, National Research Council, **Needs of the Fire Services**, Proceedings of a Symposium, 30-31 October 1968, National Academy of Sciences, Washington, D.C. 1969 (AD 694 056).

Waterman, Thomas E., "Room Flashover, Criteria and Synthesis," **Fire Technology**, Vol. 4, pp 25-31, February 1968.

Committee on Fire Research, National Research Council, **Workshop on Mass Burns**, Proceedings of a Workshop on 13-14 March 1968, National Academy of Sciences, Washington, D.C., 1969 (AD 689 495).

Vodvarka, Frank J., **Urban Burns—Full Scale Field Studies**, IIT Research Institute, Chicago, Illinois, January 1969 (AD 707 454).

Miller, Keith, et al., **Analysis of Four Models of the Nuclear-Caused Ignitions and Early Fires in Urban Areas**, Dikewood Corporation, Albuquerque, N.M., August 1970 (AD 716 807).

Goodale, Thomas, **Effects of Air Blast on Urban Fires**, URS Research Co., San Mateo, California, December 1970 (AD 723 429).

Wiersma, S.J., and Martin, S.B., **Measurements of the Dynamics of Structural Fires**, Stanford Research Institute, Menlo Park, California, August 1971 (AD 732 498).

International Association of Fire Chiefs Development Committee, **Support Assistants for Fire Emergencies**, Instructor Guide Parts A and B, and Student Manual Parts A and B, prepared for the Defense Civil Preparedness Agency, Washington, D.C., July 1971.

Cohn, B.M., Almgren, L.E., and Curless, M., **A System for Local Assessment of the Conflagration Potential of Urban Areas**, Gage-Babcock & Associates, Inc., Westchester, Ill., October 1966 (AD 643 185).

Takata, Arthur N., and Waterman, Thomas E., **Fire Laboratory Tests—Phase II, Interaction of Fire and Simulated Blast Debris**, IIT Research Institute, Chicago, Illinois, February 1972 (AD 743 210).

CPG 2-1A4
June 1973

DCPA ATTACK ENVIRONMENT MANUAL

CHAPTER 4

WHAT THE PLANNER NEEDS TO KNOW ABOUT ELECTROMAGNETIC PULSE

DEFENSE CIVIL PREPAREDNESS AGENCY
DEPARTMENT OF DEFENSE

JUNE 1973

WHY WORRY ABOUT EMP?

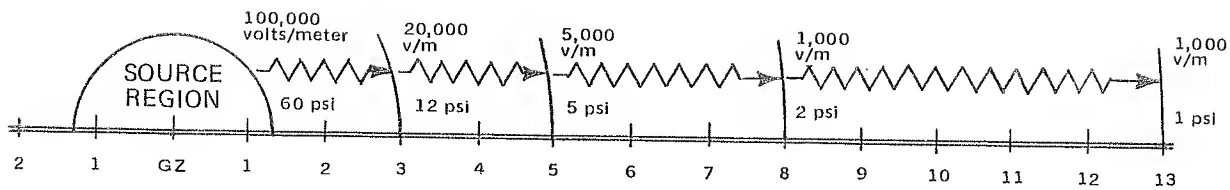
Few people have ever heard of EMP or "radio flash." It might be called the "forgotten" nuclear weapon effect. It was not mentioned in either the 1950 "Effects of Atomic Weapons" or the 1957 "Effects of Nuclear Weapons." EMP was first mentioned in a chapter on radio and radar effects in the 1962 version of the "Effects of Nuclear Weapons" but the description was brief and no hint was given as to its damaging effects.

One reason for this lack of attention has been that the energy contained in the "radio flash" is much smaller than that in the thermal pulse. We saw in Chapter 3 that where the blast overpressure is 5 psi, the thermal energy is about 100 calories per square centimeter. At the same distance from a surface burst, the radio flash energy is equivalent to much less than one calorie per square centimeter.

We know that sunlight can be focused by a magnifying glass so as to ignite paper. If magnifying glasses or their equivalent were common in target areas, we would need to be concerned about very low levels of thermal radiation in nuclear attack. Fortunately, this is not the case. But natural energy collectors for radio frequencies are widespread. They magnify the weak "radio flash" somewhat as a magnifying glass does sunlight.

Anyone who has hooked up an old radio to a bedspring knows that almost any metallic object can collect energy from radio waves. Any long wire can pick up the energy in the electromagnetic field and then deliver it in the form of current and voltage pulses to the attached equipment. The larger or longer the conductor, the greater the amount of energy collected. For example, the short antenna of an automobile radio will collect less energy than a large broadcast station transmitting antenna. Typical collectors of EMP energy include long exposed cable runs, piping or conduit, large antennas, metallic guy wires, power and telephone lines, and even shallow-buried pipes and cables, long runs of electrical wiring in buildings, and the like. Sufficient energy can be collected by these means to cause damage to attached electrical and electronic equipment.

EMP FROM A 5–MT SURFACE BURST

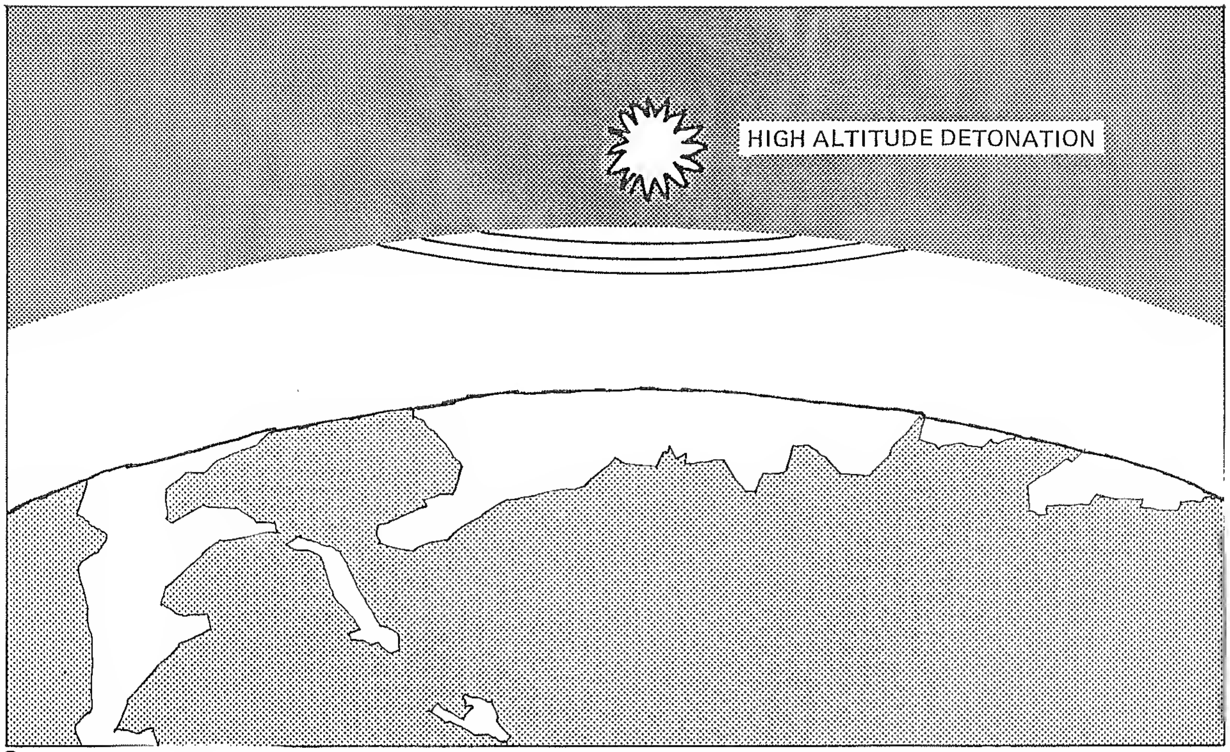


DISTANCE FROM GZ, MILES

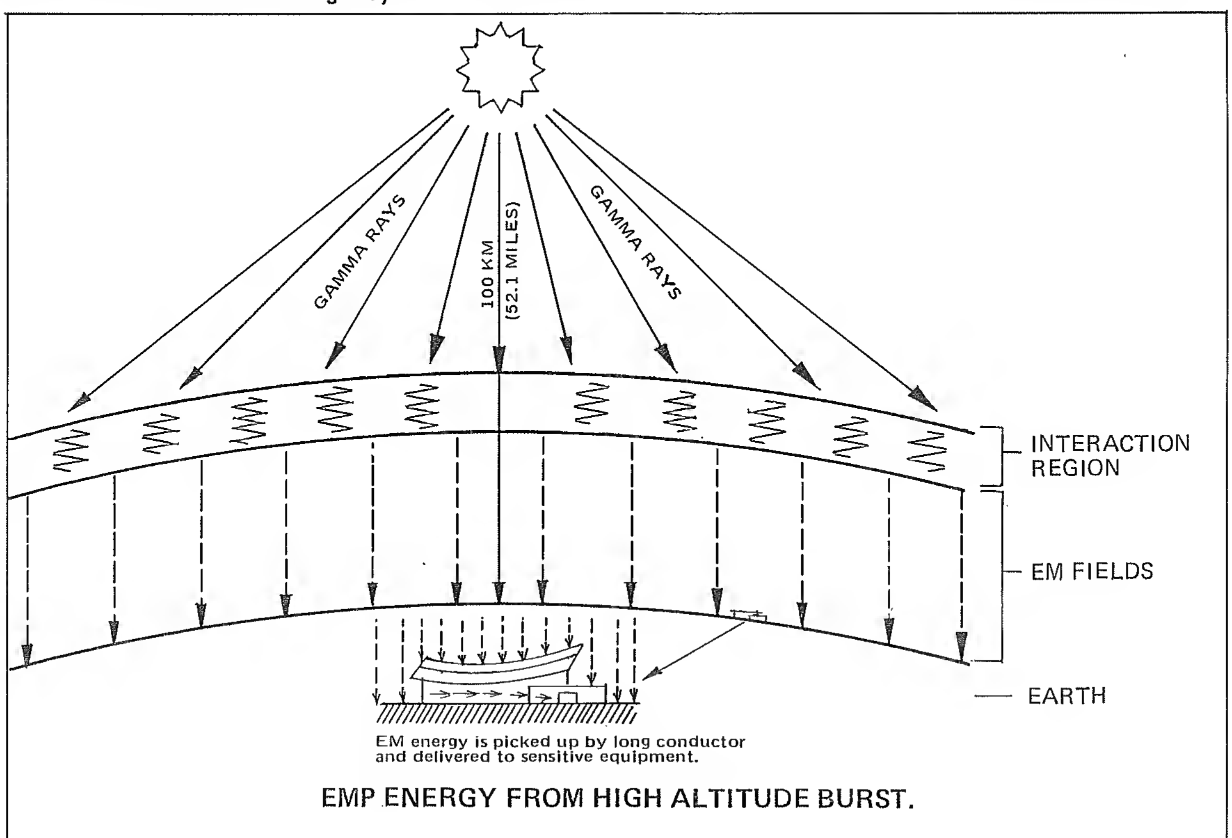
COMPARISON OF ELECTROMAGNETIC FIELDS

SOURCE	INTENSITY (volts per meter)
EMP	UP TO 100,000
RADAR	200
RADIO COMMUNICATION	10
METROPOLITON "NOISE"	0.1

Source: Defense Nuclear Agency



Source: Defense Nuclear Agency



PANEL 4 From Survive, November-December 1969.

EMP COVERAGE

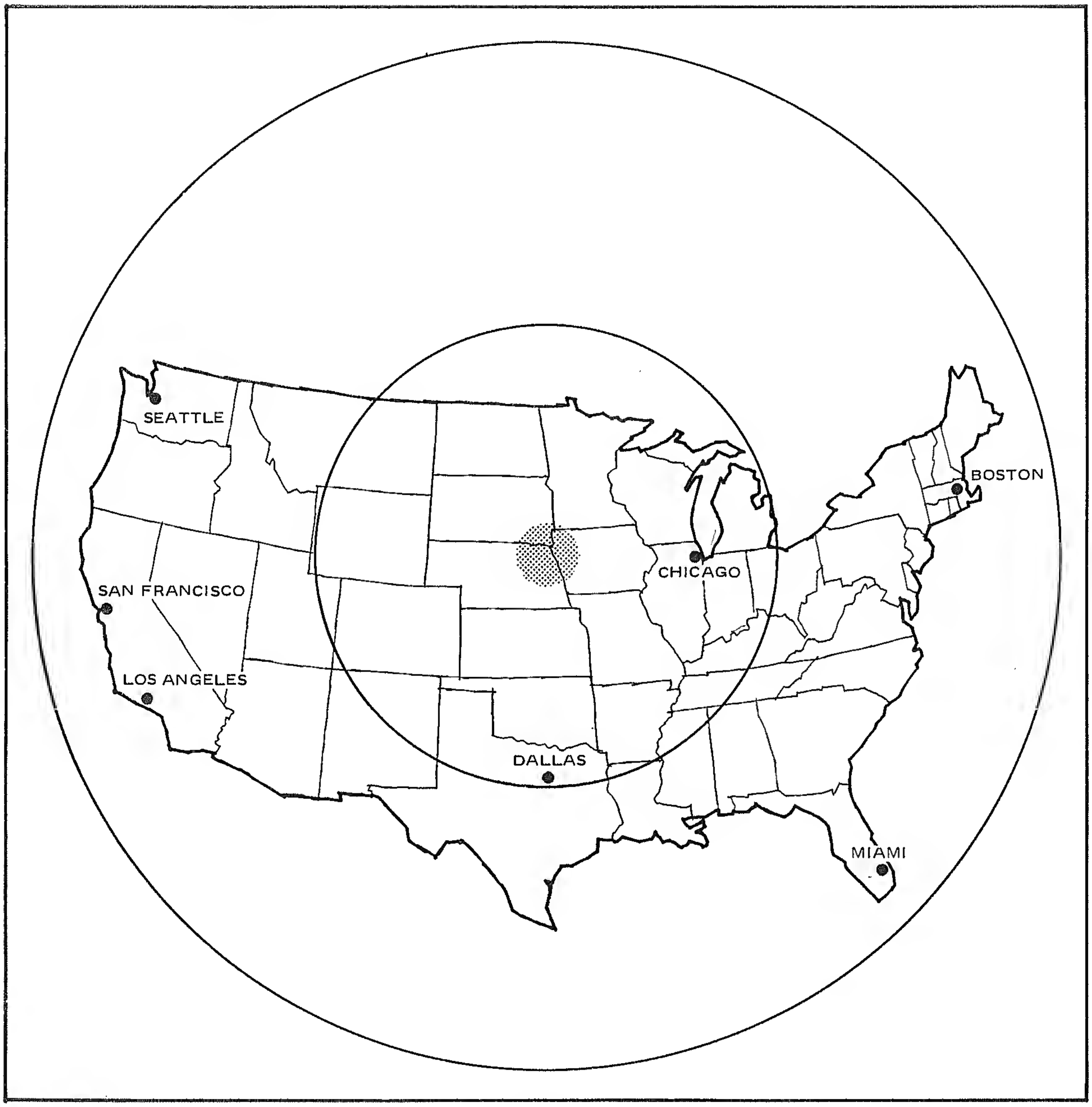
In the case of an exoatmospheric burst, blast damage does not occur and other effects are minor except for the EMP. The source region at 12½ to 25 miles above the earth's surface can be quite large, perhaps a thousand miles in diameter. As a consequence, the radiated fields from this source region can cover a substantial fraction of the earth's surface.

A typical high-altitude burst over Omaha, Nebraska, is shown here. Within the circle passing through Dallas, Texas, ground-level fields of a few tens of thousands of volts per meter would be created. The outer circle shows that a few kilovolts per meter would occur everywhere within the contiguous 48 states.

That these pulses can cause damage to electrical and electronic equipment is not a matter of scientific theory. The failure of approximately 30 strings of street lights on Oahu at the time of the Starfish detonation about 750 miles away over Johnson Island was the most publicized effect during the weapons test series Operation FISHBOWL in 1962.

High-altitude bursts are no longer unlikely. The deployment of those ballistic missile defenses permitted by the recent treaty with the Soviet Union would include the use of megaton-yield warheads to intercept incoming weapons outside the atmosphere. Even if this were not in prospect, the effectiveness of EMP in interrupting communications would make it probable that some of the thousands of warheads discussed in Chapter 1 would be used for this purpose.

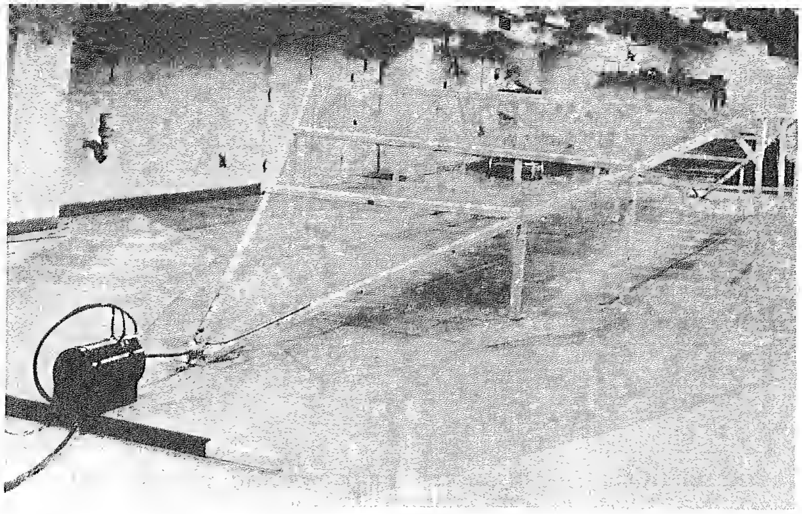
An implication for operational planning is that a potential EMP threat must be anticipated in every locality during the first minutes and perhaps hours after a nuclear attack is initiated.



EMP GROUND COVERAGE OF HIGH ALTITUDE BURSTS

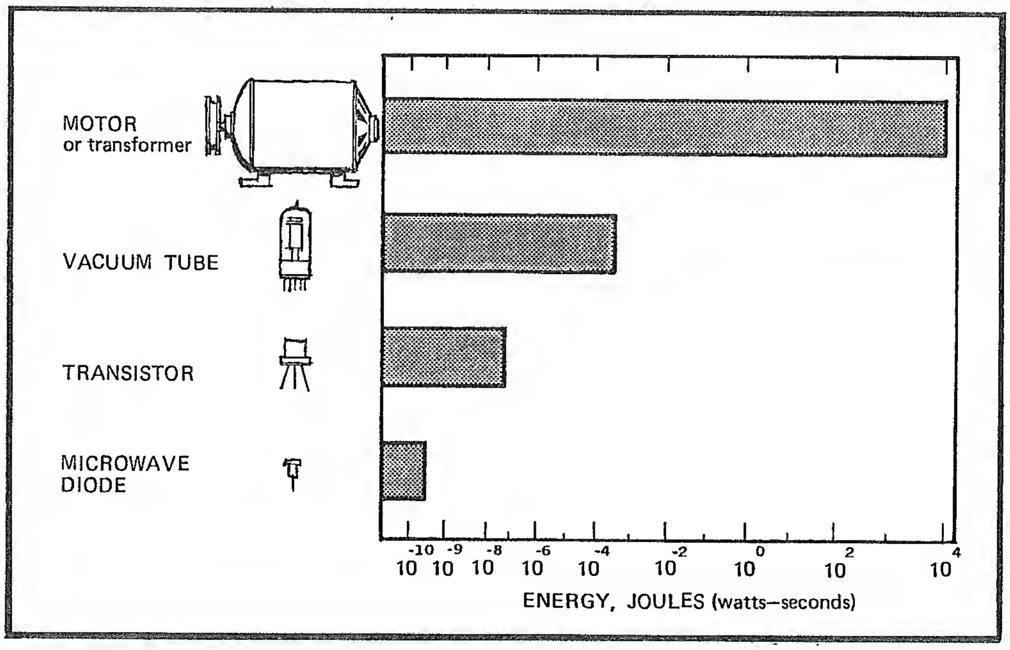
Source: Defense Nuclear Agency

PANEL 5



ONE TYPE OF EMP SIMULATOR

IITRI Laboratory photograph.



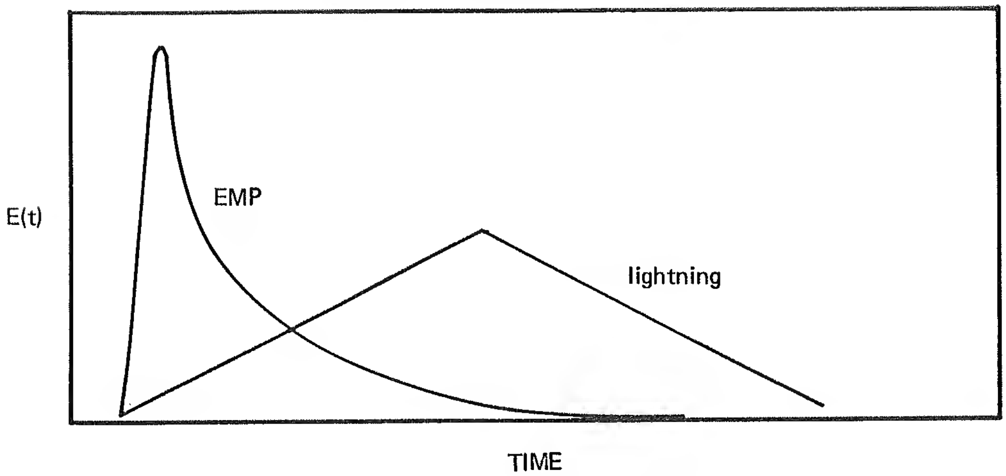
SENSITIVITY OF VARIOUS COMPONENTS

NOTE: 300 feet of wire can absorb about 1/10 to 40 joules of energy depending on orientation and proximity to other conductors.

Source: Defense Nuclear Agency

PANEL 6

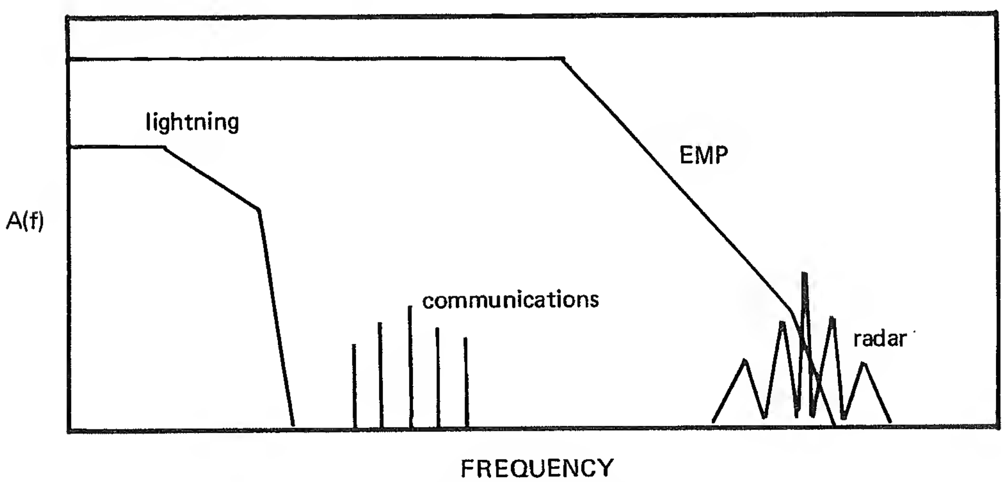
TIME HISTORY
COMPARISON WITH LIGHTNING



NOTE: Rapid rise of EMP pulse

Source: Defense Nuclear Agency

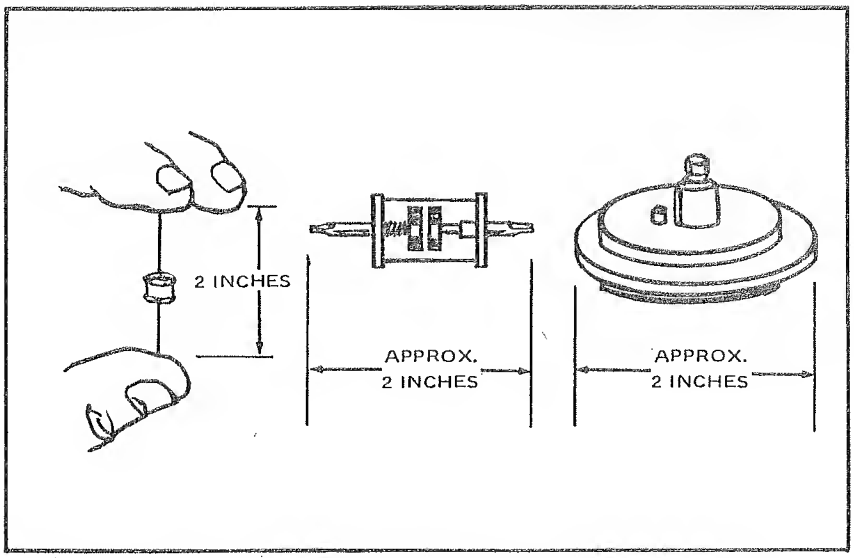
SPECTRUM COMPARISON



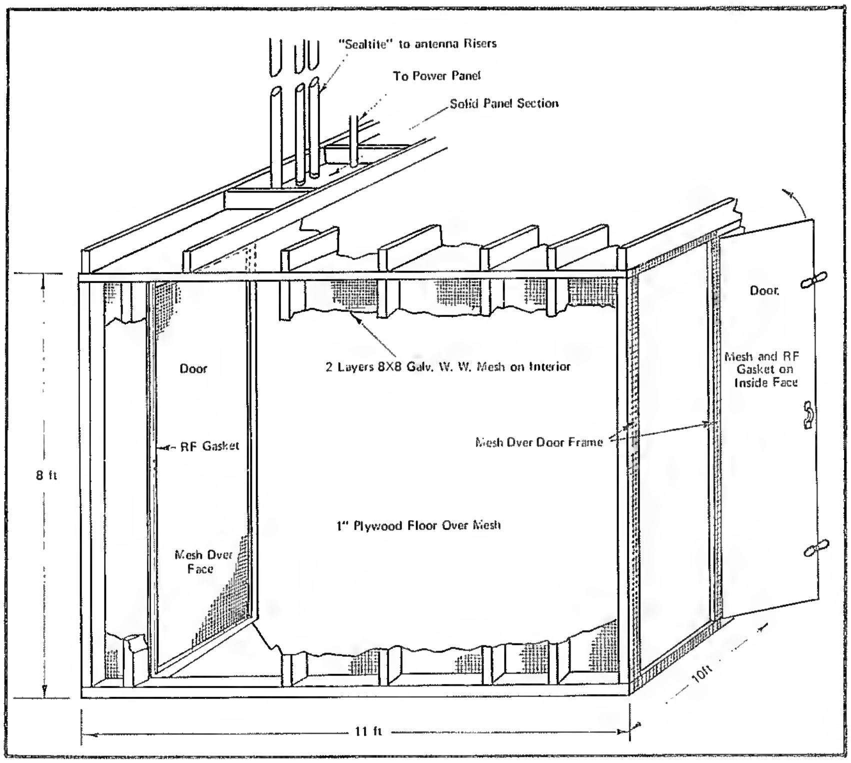
NOTE: Broad frequency range of EMP

Source: Defense Nuclear Agency

PANEL 7



GAS-GAP SURGE ARRESTOR (also called spark-gaps)

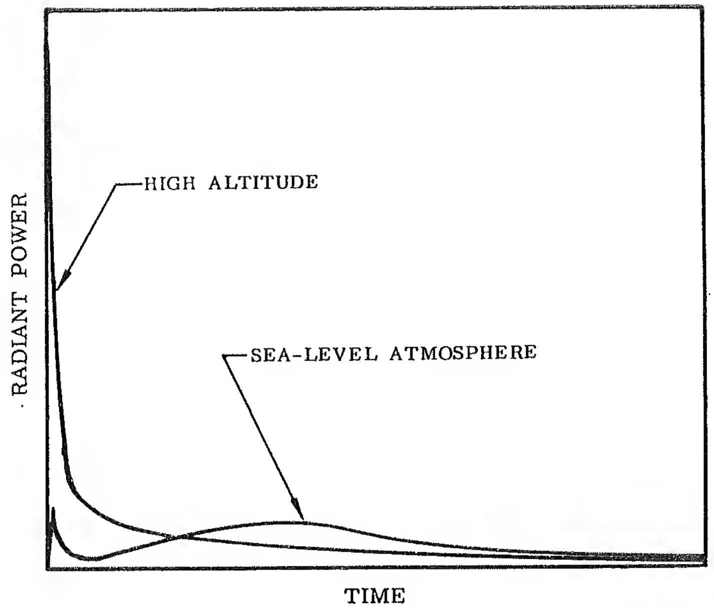


SHIELDED BOX

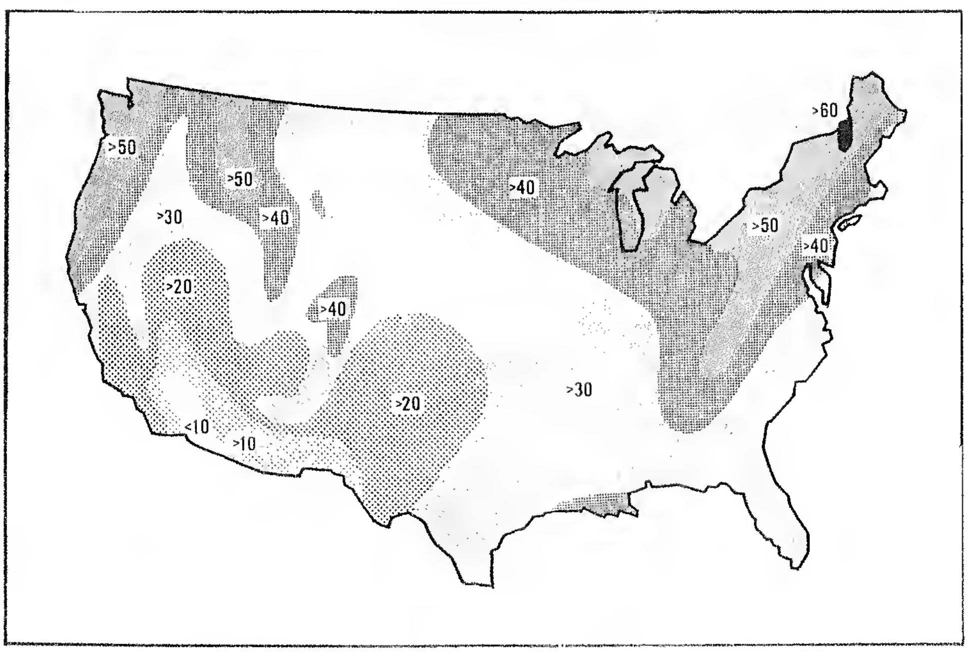
PANEL 12

SUSCEPTIBILITY TO RADIO BLACKOUT

Radio Band	Frequencies	Example	Effects
LF	30 - 300 KHZ	DIDS	Least affected
MF	300 - 3000 KHZ	EBS	Some distant interference
HF	3000 - 30,000 KHZ	RACES	Many hours
VHF	30,000 KHZ - 300 MHZ	High-band Public Safety	Few seconds to minutes
UHF	300 - 3000 MHZ	TV, Latest Public Safety	Little effect
SHF	3 - 30 GHZ	Microwave and Satellite	Virtually no effect



COMPARISON OF RATES OF THERMAL ENERGY
RELEASE FOR MEGATION WEAPONS



PERCENTAGE OF ANNUAL "OPAQUE" CLOUDINESS

PANEL 15

SUMMARY

One final point should be made about EMP effects. We do not have to concern ourselves about the effects upon people as we did in Chapters 2 and 3. Without considerable focusing, the EMP energy is totally harmless to living things. Standing in the open, one would literally not feel a thing with respect to the strongest EMP pulse. However, the energy collected in a long wire might cause electrocution or a burn, if a person were touching it at the time. Such conditions are not generally expected.

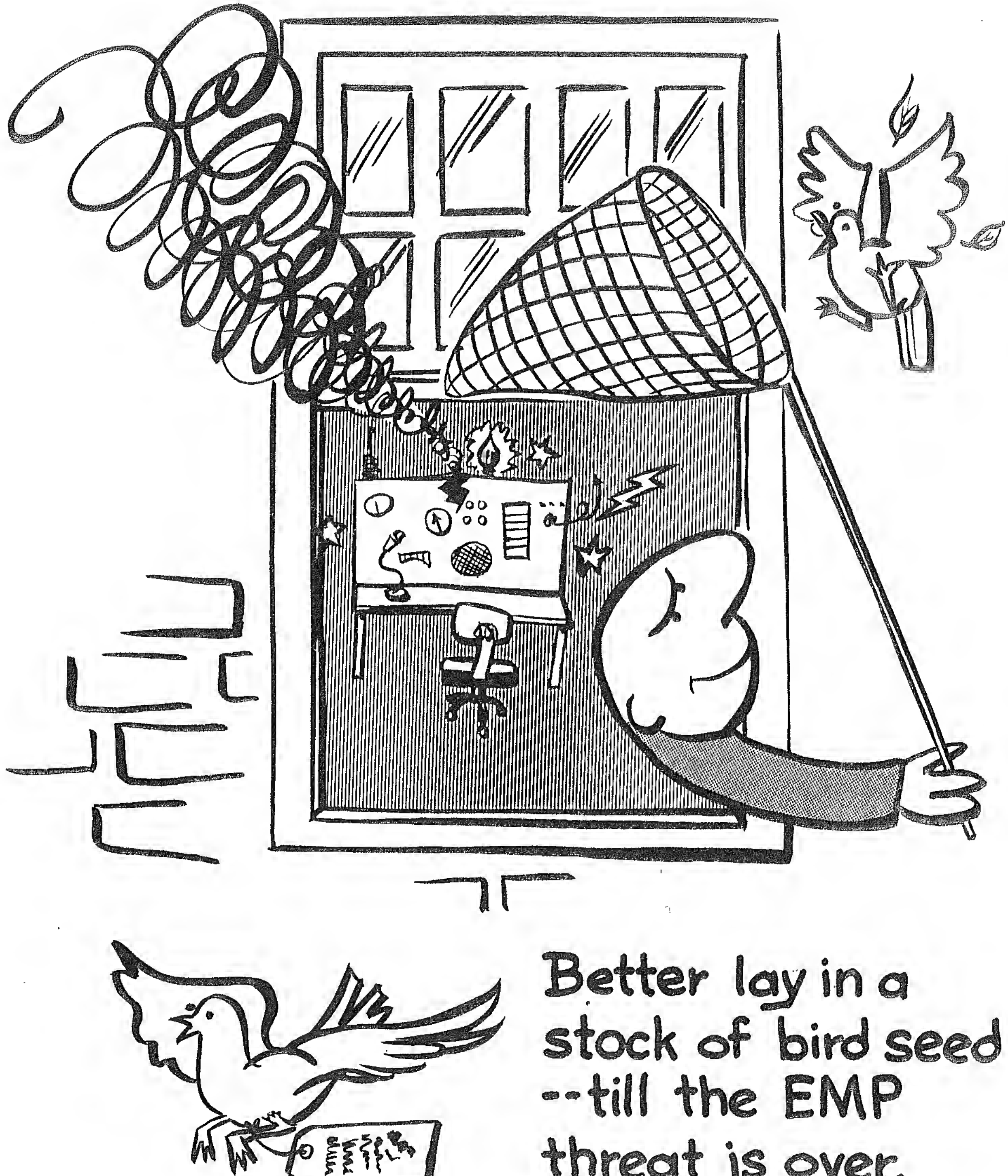
With respect to the protection of communications and electrical equipment, recent research results have been incorporated into the following publications:

EMP Threat and Protective Measures, DCPA TR-61, August 1970.

EMP Protection for Emergency Operating Centers, DCPA TR-61A, May 1971.

EMP Protective Systems, DCPA TR-61B, revised July 1972.

EMP Protection for AM Radio Broadcast Stations, DCPA TR-61C, May 1972.



Courtesy of Don Clark, U.S. Naval Civil Engineering Laboratory.

PANEL 16

CPG 2-1A5
June 1973

DCPA ATTACK ENVIRONMENT MANUAL

CHAPTER 5

WHAT THE PLANNER NEEDS TO KNOW ABOUT INITIAL NUCLEAR RADIATION

DEFENSE CIVIL PREPAREDNESS AGENCY
DEPARTMENT OF DEFENSE

JUNE 1973

SOMATIC AND GENETIC EFFECTS

The statements shown here were made in 1967 by Dr. Charles L. Dunham, Chairman of the Division of Medical Sciences, National Research Council. He was summarizing the views of the professional community at a symposium on the consequences of a nuclear war in which about 3500 megatons were assumed to be detonated in the United States. As we saw in Chapter 1, an attack perhaps twice as heavy could be delivered today. In the larger war, the number of survivors would be less but the average radiation dose received by the survivors would be much the same as Dr. Dunham's assumption of 200R. The first quotation refers to the late somatic effects discussed in the previous panel. For perspective, about 20,000 new cases of leukemia are diagnosed each year in the U.S. About 69,000 deaths occurred from lung cancer in 1971, most due to smoking.

The second quotation refers to the genetic effects—those affecting future generations. Genetic injury does not affect the health of exposed individuals in any way and can be detected only by statistical studies of their descendents. So far, searches for evidence of abnormalities in children conceived after one or both of the parents were irradiated have been unsuccessful. Using pessimistic assumptions, calculations have been made that suggest that major defects in newborn babies of succeeding generations might increase to 5 percent from the present rate of 4 percent, assuming that all parents received a dose of 200 to 250R following attack.

Both somatic and genetic effects are believed to be directly related to the dose received by the surviving population. Thus, if by effective civil defense planning, the protection provided the population could be doubled, the numbers shown here would be cut in half.

PANEL 7

GENERAL PREDICTIONS*

"20,000 additional cases per year of leukemia during the first 15 or 20 years postattack followed by an equal number of cases of miscellaneous cancers, added to the normal incidence in the next 30 to 50 years, would constitute the upper limiting case. They would be an unimportant social, economic, and psychological burden on the surviving population."

"The genetic effects would be lost as at Hiroshima and Nagasaki, in all the other 'background noise.' "

*From Proceedings of the 1967 Symposium on Postattack Recovery from Nuclear War, National Academy of Sciences, April 1968 (AD 672 770).

RELATIONSHIP OF BLAST AND INITIAL NUCLEAR RADIATION

(Near-Surface and Surface Bursts)

Blast Overpressure (psi)	Nuclear Radiation (Roentgens)		
	1 MT	5 MT	25 MT
1	Neg.	Neg.	Neg.
2	Neg.	Neg.	Neg.
5	Neg.	Neg.	Neg.
12	280 (260)*	7 (7)	Neg.
20	3600 (3200)	430 (420)	10 (10)

*Values in parentheses are for surface bursts.

TYPICAL INR PROTECTION FACTOR RANGES RELATIVE TO BLAST PROTECTION

Blast Preference	Description
A	Subway stations, tunnels, mines, and caves with large volume relative to entrances. (10 - 10,000)
B	Basements (10 - 100) and sub-basements (100 - 1000) of massive (monumental) masonry buildings.
C	Basements (10 - 100) and sub-basements (100 - 1000) of steel and reinforced-concrete framed buildings having flat slab or slab and beam ground floor construction.
D	First three floors of buildings with "strong" walls. (2 - 5)
E	Basements of wood-frame (4 - 8) and brick veneer residences. (5 - 10)
F	Fourth and higher floors of buildings with "strong" walls. (1 - 5)
G	Basements of steel and reinforced-concrete framed buildings with flat plate ground floor. (10 - 100)
H	First three floors of buildings with weak walls, brick buildings and residences. (2 - 5)
I	Fourth and higher floors of buildings with weak walls. (1 - 5)

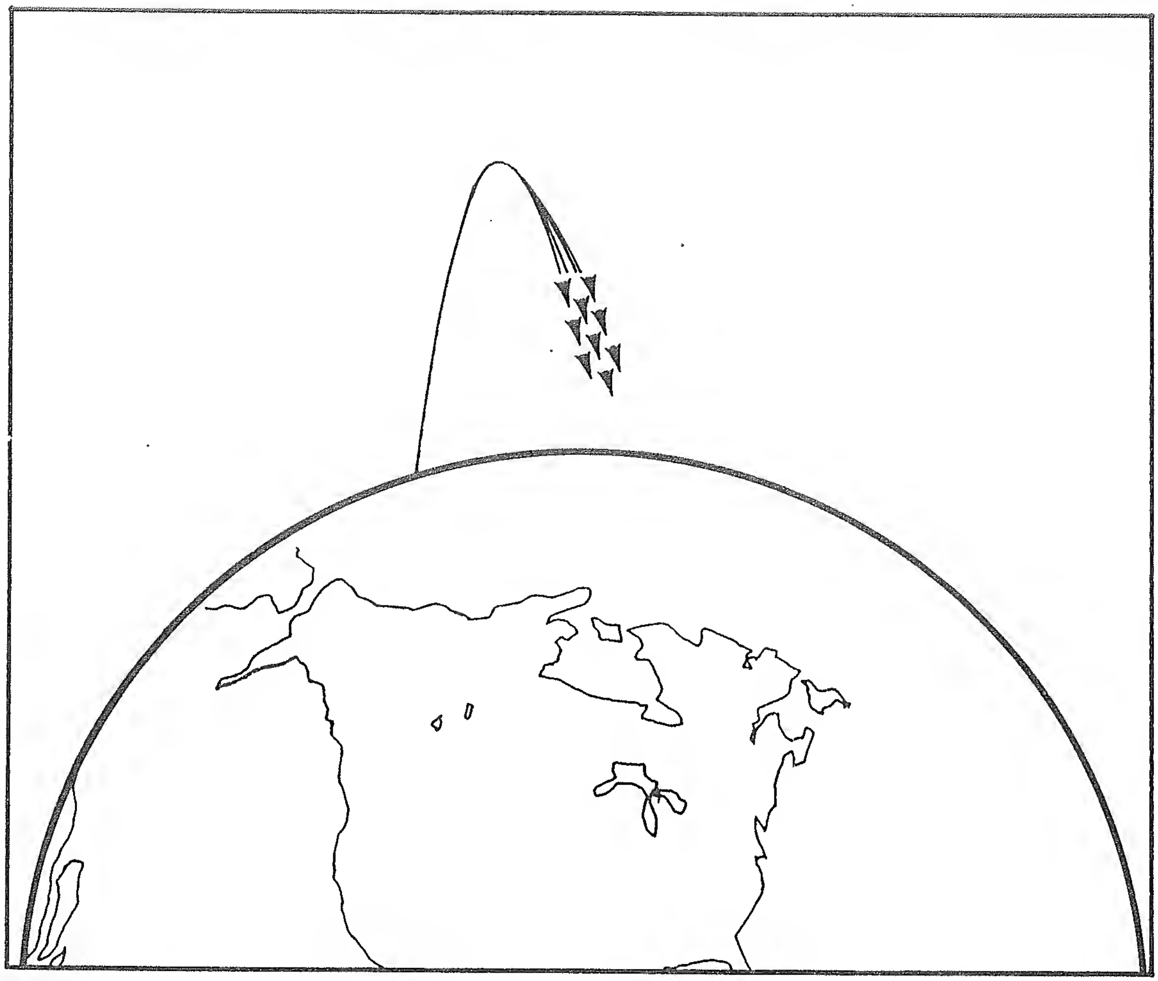
THE POSSIBLE USE OF "SMALL" WEAPONS

In Chapter 1 we alerted the emergency planner to the fact that there has been and likely will continue to be a trend toward larger numbers of smaller-yield nuclear weapons fitted on missiles as multiple warheads. We noted that many U.S. missile systems have already been modified in this fashion and that the Soviets may be beginning to do so.

Some of the motivation to use multiple warheads has stemmed from a perceived need to complicate the task of developing ballistic missile defense systems, commonly called ABM systems, by providing many separate incoming warheads. But this objective is not the whole motivation Although the total megatonnage that can be delivered in the form of multiple warheads is substantially less than that delivered as single weapons, the sum of the separate direct effects areas are very much the same. The blast effects would be somewhat lessened; the thermal effects would be somewhat increased. As we shall see, the relative effects of initial nuclear radiation are greatly increased, so that survival in ordinary structures may be limited by the lack of initial radiation protection. Since many smaller detonations may cover a sprawling metropolitan area more efficiently or permit more effective attack against separated industrial facilities, airports, and other key targets, the trend toward warheads in the kiloton-yield range may continue despite agreements to limit the deployment of missile defense systems.

Small-yield nuclear weapons in the range of tens to hundreds of kilotons also may differ from large megaton-range weapons in the nuclear processes employed in creating an explosive release of energy. About half the energy in large-yield weapons comes from fission of heavy elements like uranium. The remainder comes from fusion of light elements, such as hydrogen. Small-yield weapons may use only the fission process, as was the case at Hiroshima and Nagasaki. In describing large-yield weapons, we have assumed 50 percent fission yield. In describing small weapons, we will assume 100 percent fission yield.

PANEL 10



PANEL 10

INITIAL NUCLEAR RADIATION FROM "SMALL" WEAPONS

When the explosive power of a nuclear weapon is changed, the extent of blast overpressure varies as the cube root of the change in explosive power. Thus, the extent for a 5-KT detonation is 1/10 that of a 5-MT detonation (one that has 1,000 times more explosive power) and the extent for a 40-KT detonation is 1/5 that of a 5-MT burst. The extent of initial nuclear radiation is reduced somewhat but not nearly as much as are the blast overpressures. Consequently, the INR exposure becomes increasingly large at a given overpressure as the weapon yield is reduced, as shown here.

At these short ranges (5-psi overpressure occurs at a mile or two from ground zero), neutrons are an important constituent of initial nuclear radiation in addition to gamma radiation. Whereas gamma radiation is electromagnetic radiation, neutrons are extremely tiny particles of matter ejected from the nuclei of atoms involved in the nuclear detonation. Neutrons have about the same effectiveness in causing biological damage as gamma rays. The use of Rem (Roentgen-equivalent-man) in the table merely signals that radiation other than gamma radiation is contributing to the exposure.

For 40-KT detonations, initial nuclear radiation is significant in the moderate damage region (2 to 5 psi). Further, our imaginary person in the open at 10 psi (about 7/10 mile from Ground Zero) is exposed to about 8000 Rem. The protection afforded by a residential basement (5 to 10 IPF) would be insufficient. Only the better parts of large building basements, sub-basements, and subways would permit survival.

At higher yields (over 100 KT), INR doses in the area of severe damage would not be as high but basement protection would be essential and survival possibilities are clearly limited by the initial nuclear radiation exposure.

RELATIONSHIP OF BLAST AND INITIAL NUCLEAR RADIATION

(Near-Surface Bursts)

Blast Overpressure (psi)	Nuclear Radiation (Rem)		
	40 KT	100 KT	1 MT
1	1	Neg.	Neg.
2	5	Neg.	Neg.
5	560	170	Neg.
12	10,000	5,500	280
20	34,000	23,000	3,600

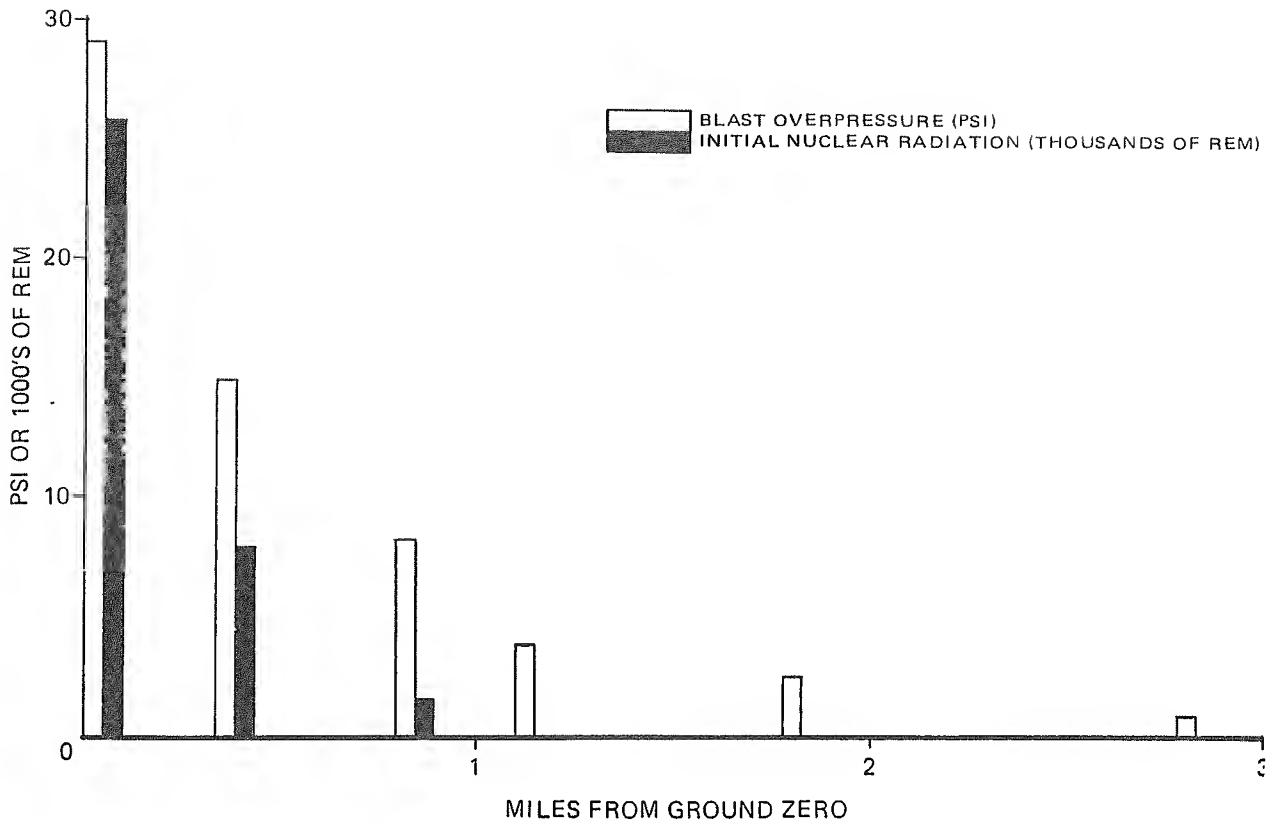
WHAT HAPPENED AT HIROSHIMA

At Hiroshima, casualties were the result of a combination of the three major "direct" effects (blast, thermal radiation, and initial nuclear radiation) but blast and thermal radiation seemed to be the dominant causes. The weapon was relatively small (about 12 KT) and exploded very high (about 1900 feet) relative to its size. It was a clear morning with a large number of people in the streets at the time. The maximum blast overpressure was about 30 psi on the ground directly under the bomb and the initial nuclear radiation dose there was about 26,000 Rem. However, the initial nuclear radiation exposure reduces rapidly with increased distance from the weapon. Both the overpressures and INR doses for several distances at Hiroshima are shown in this bar chart.

At 8-psi blast overpressure, where more than half the people in Japanese houses were killed, the initial nuclear radiation exposure was about ½ percent of its maximum or 155 Rem, too low to cause death. If the weapon had been detonated nearer the ground (within a few hundred feet), initial nuclear radiation would have been a more important cause of death than either blast or thermal radiation. For example, at 8 psi, the initial nuclear radiation exposure in the houses would have been 2800 Rem.

In discussing the threat of initial nuclear radiation, we have assumed that surface or near-surface detonations would occur. If this is not the case, this threat will be greatly diminished.

BLAST AND INR* AT HIROSHIMA



*From Auxier, J.A., et al., **Free-field Radiation-dose Distributions from the Hiroshima and Nagasaki Bombings**, Health Physics, Vol. 12, 1966.

PANEL 12

SUGGESTED ADDITIONAL READING

Effects of Nuclear Weapons, Revised Edition 1964, Glasstone, S., (editor), Chapters II VIII, and XII, Superintendent of Documents, GPO.

French, R.L., and Mooney, L.G., **Initial Radiation Exposure from Nuclear Weapons**, Radiation Research Associates, Inc., Report RRA-T7201, July 1972 (AD 745-906).

National Committee on Radiation Protection, **Exposure to Radiation in an Emergency**, Report No. 29, January 1962.

Proceedings of the 1967 Symposium on Postattack Recovery from Nuclear War, National Academy of Sciences, April 1968 (AD 672-770).

Auxier, J.A., et al, **Free-field Radiation-dose Distributions from the Hiroshima and Nagasaki Bombings**, Health Physics Vol. 12, 1966.

CPG 2-1A6
June 1973

DCPA ATTACK ENVIRONMENT MANUAL

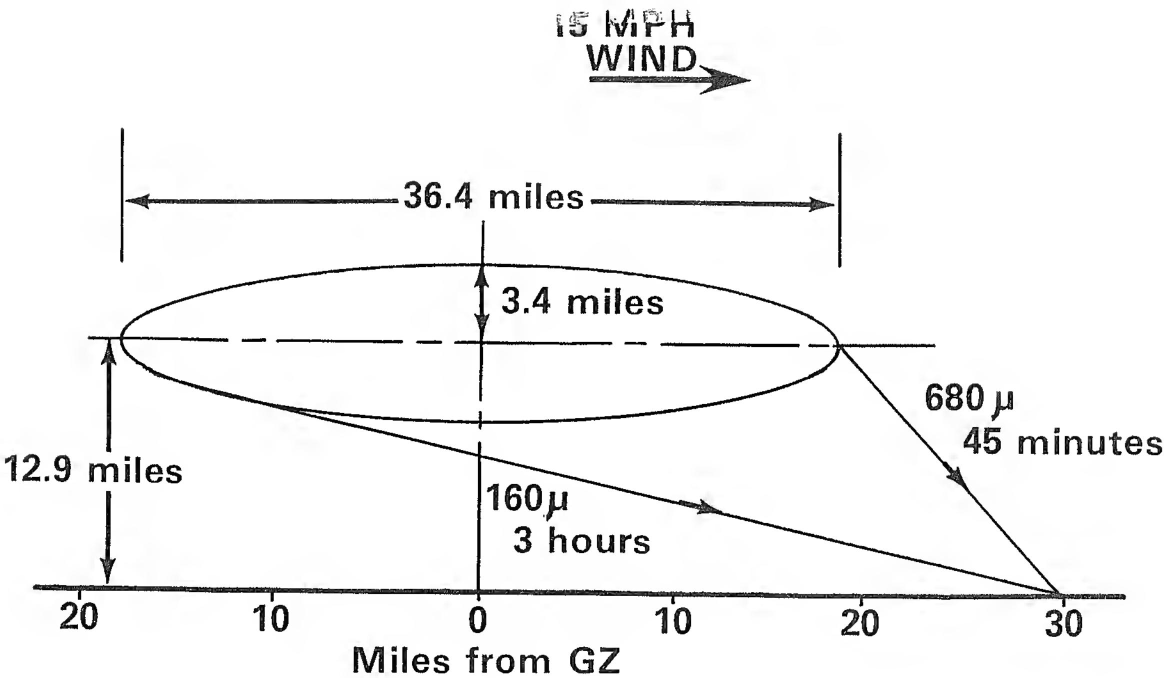
CHAPTER 6

WHAT THE PLANNER NEEDS TO KNOW ABOUT FALLOUT

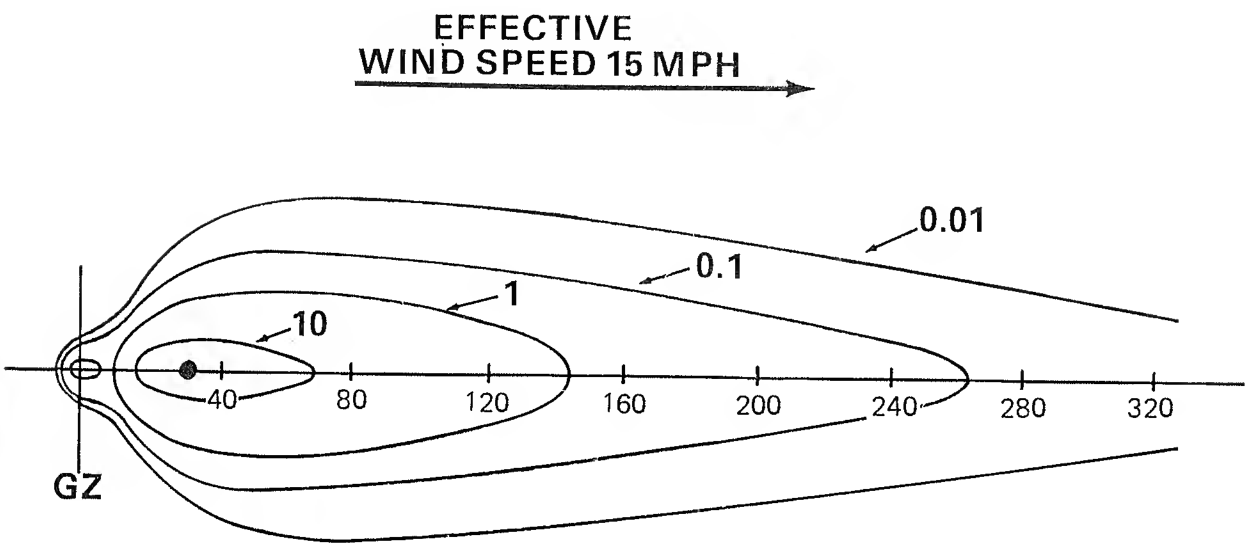
DEFENSE CIVIL PREPAREDNESS AGENCY
DEPARTMENT OF DEFENSE

JUNE 1973

CLOUD FALLOUT
(5MT Surface Detonation)

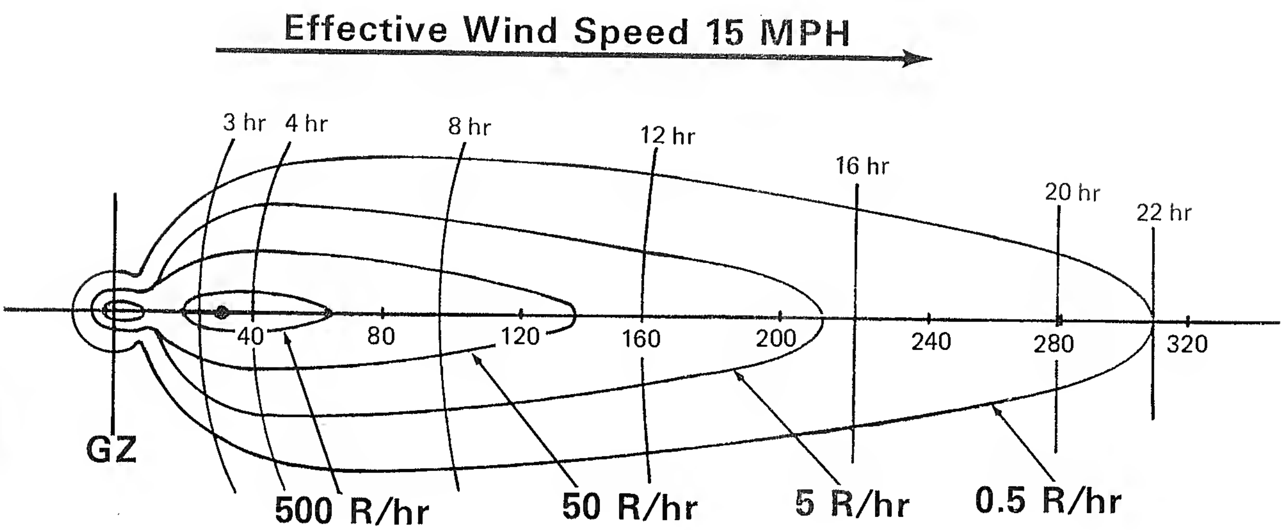


MASS DEPOSITION PATTERN
(5 MT SURFACE BURST)



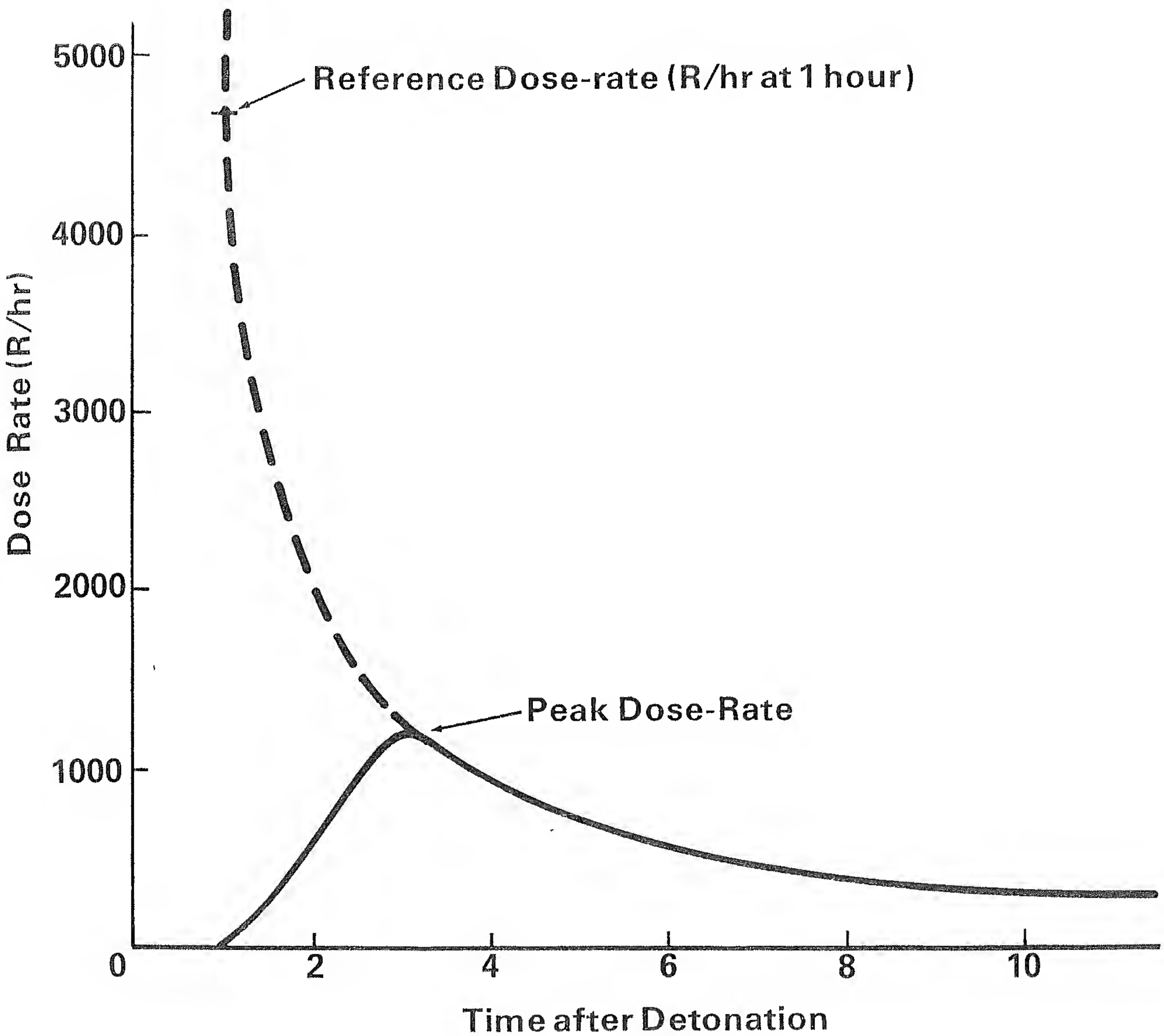
- Distances in miles
- Contours in grams per square foot

PEAK DOSE-RATE PATTERN
(5 MT Surface Burst)



- Distances in miles
- Contours in roentgens per hour (true ionization rate at three feet above a smooth infinite plane)
- Vertical curves show peaking time in hours after detonation
- Fission yield 50%.

FALLOUT SITUATION AT 30 MILES DIRECTLY DOWNWIND FROM 5 MT SURFACE BURST
(15 MPH WIND SPEED)



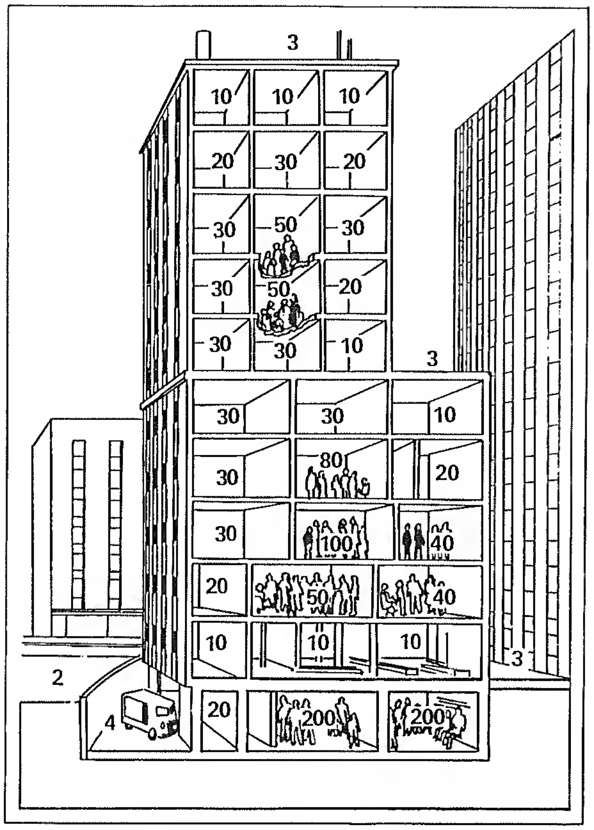
DOSE-PENALTY TABLE

Acute Effects \ Roentgen Exposure Dose in Any	1 Week	1 Month	4 Months
Medical Care Not Needed	150	200	300
Some Need Medical Care Few if Any Deaths	250	350	500
Most Need Medical Care 50% + Deaths	450	600	*

*Little or no practical consideration.

DOSES AT 30 MILES DOWNWIND
(5-MT surface burst; 15 MPH wind)

Time	In Open	In Shelter 46	In Shelter 76
1 Week	11,400	248	150
1 Month	13,500	294	178
4 Months	15,000	326	197


3
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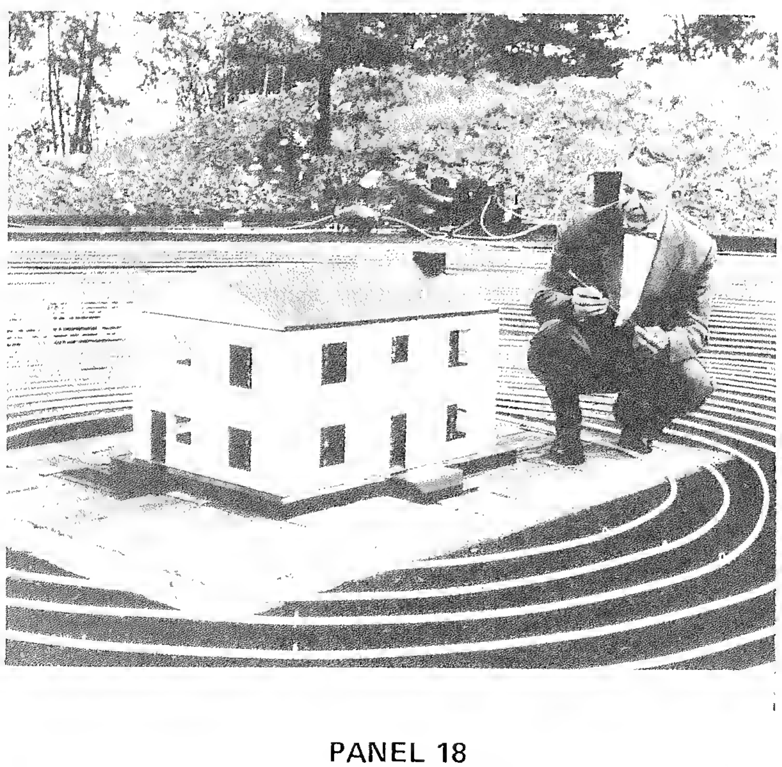
200



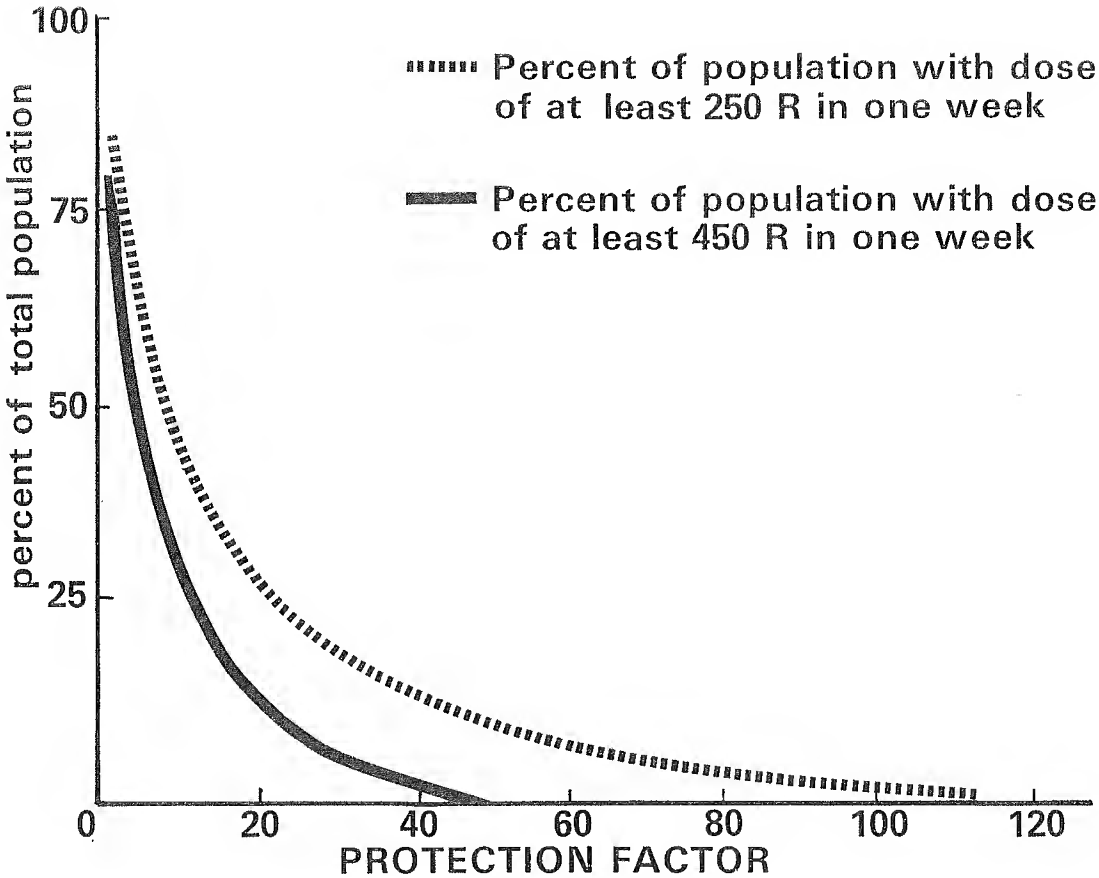
PANEL 18

TYPICAL FALLOUT PROTECTION FACTOR RANGES

RELATIVE TO BLAST PROTECTION

Blast Preference	Description
A	Subway stations, tunnels, mines, and caves with large volume relative to entrances. (1000 - 10,000)
B	Basements ans sub-basements of massive (monumental) masonry buildings. (100 - 1000)
C	Basements and sub-basements of steel and reinforced-concrete framed buildings having flat slab or slab and beam ground floor construction. (100 - 1000)
D	First three floors of buildings with "strong" walls. (20 - 80)
E	Basements of wood-frame and brick-veneer residences. (10 - 50)
F	Fourth and higher floors of buildings with "strong" walls. (20 - 100)
G	Basements of steel and reinforced-concrete framed buildings with flat plate ground floor. (100 - 200)
H	First three floors of buildings with weak walls, brick buildings and residences. (20 - 80)
I	Fourth and higher floors of buildings with weak walls. (20 - 100)

ONE-WEEK DOSE AFTER LARGE ATTACK FOR VARIOUS PROTECTION FACTORS



PANEL 20

PROTECTION IN RESIDENTIAL BASEMENTS

We noted in Chapter 2 that home basements could play an important role in improving survival from blast effects. They can also play an important role in providing protection against fallout radiation. In most parts of the country outside of the downtown areas of cities, the amount of fallout shelter identified in the National Fallout Shelter Survey (NFSS), which is located in large buildings, is insufficient for the population that needs shelter.

About half the homes in the United States have basements, but, as shown on this map, they tend to be concentrated in the northern part of the country. A small proportion of homes have basements in the South, Southwest, and Far West sections. Even these could be of great value if neighbors shared with neighbors. The average residential basement has an area greater than 1000 square feet. The standard shelter space in the NFSS buildings is 10 square feet. The usual emergency housing space allotment in peacetime natural disasters is 40 square feet. Thus, from 25 to 100 persons could be sheltered in the average home basement, if necessary.

The fallout protection afforded by home basements can be estimated in the following way:

(1) Single-story homes with average basement wall exposures (i.e., above ground) less than 2 feet will provide at least PF 20 throughout the basement.

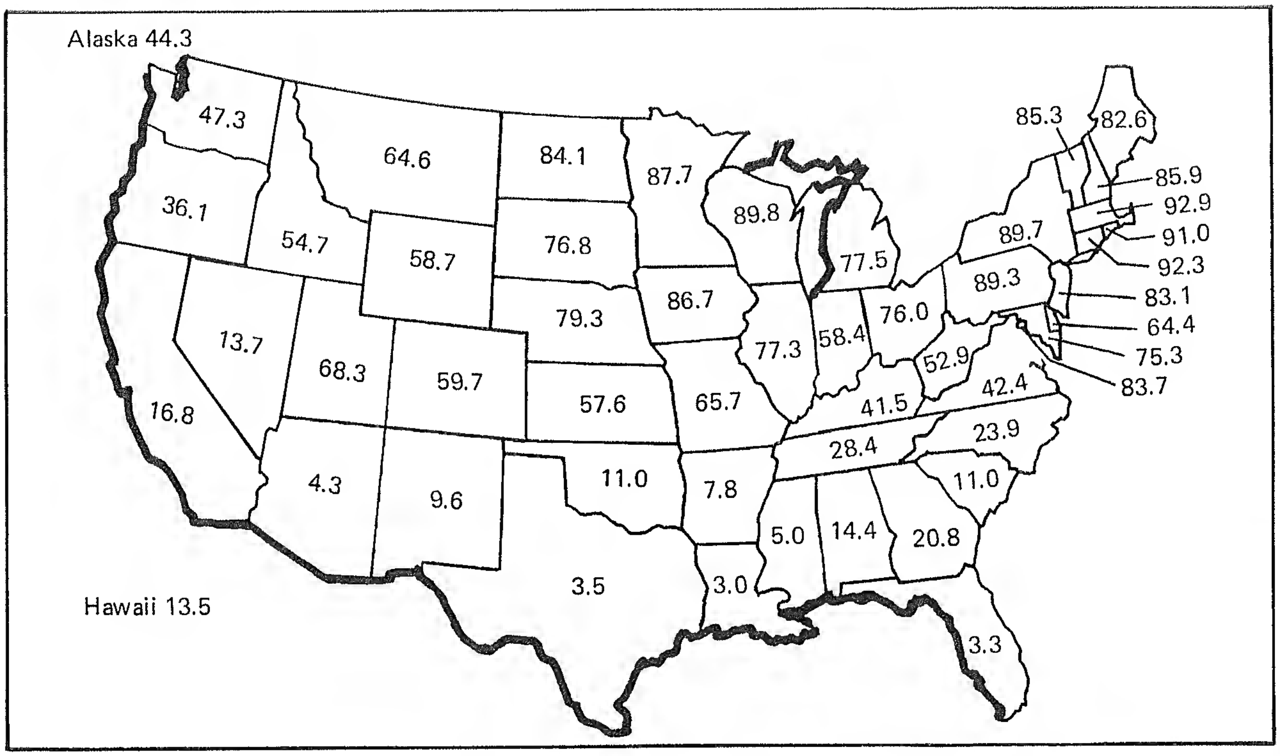
(2) Homes with 2 or more stories and 2 feet or less average basement wall exposure will provide at least PF 40 throughout the basement.

(3) Single-story homes with average basement wall exposure greater than 2 feet can be improved to PF 20 by sandbagging the exposed walls or mounding earth against them.

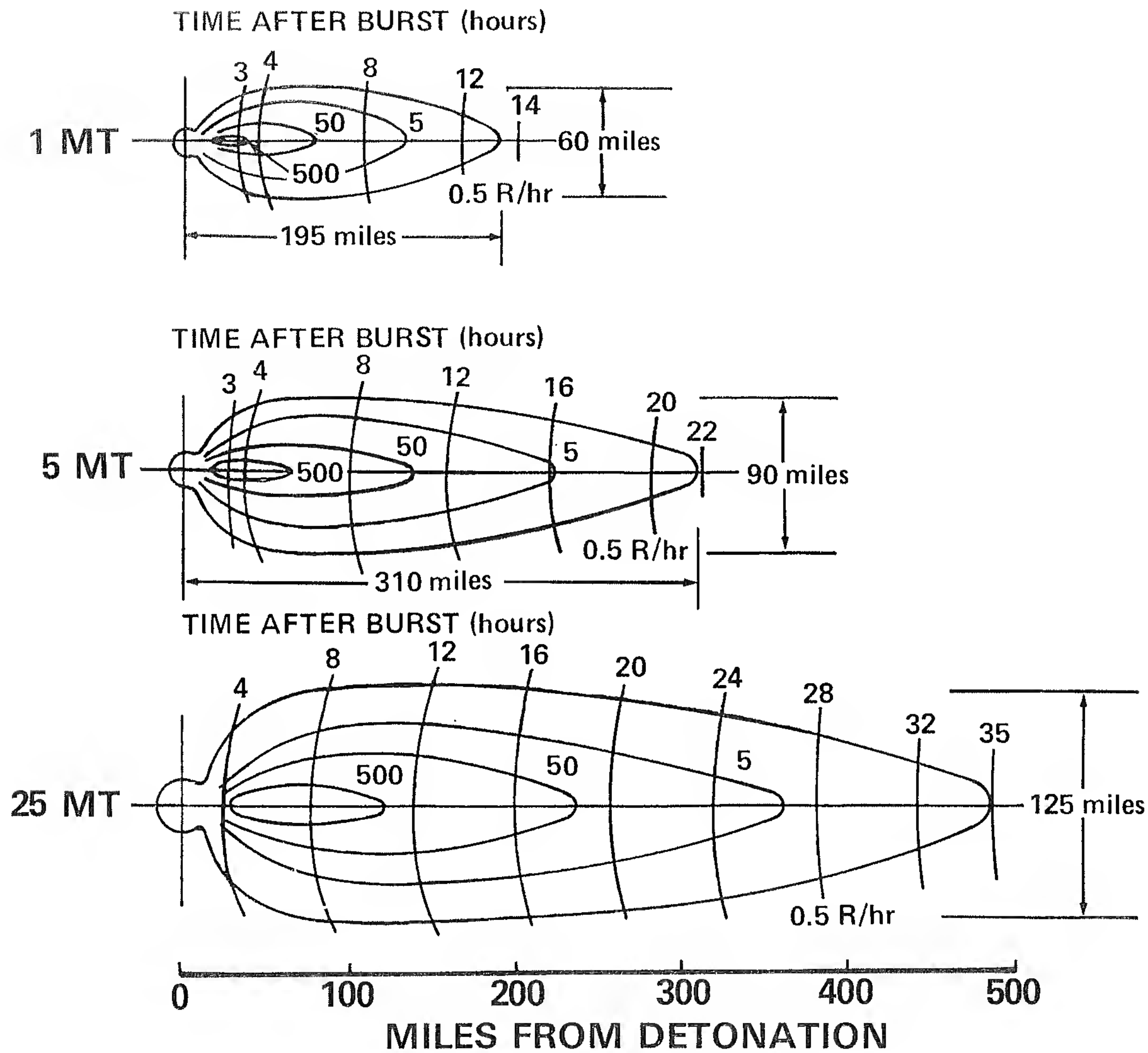
(4) Similarly, multi-story homes with basement wall exposure greater than 2 feet can be improved to PF 40 by sandbagging or mounding earth.

Generally, fallout protection in home basements is least in the center of the basement and greatest in the corners and along the walls.

PERCENTAGE OF HOMES WITH BASEMENTS



FALLOUT PATTERNS
(PEAK DOSE RATES AND TIME OF PEAK)
FOR 15 MPH EFFECTIVE WIND



DOSE IN ROENTGENS TO KILL HALF THE ANIMALS IN BARNS, PENS, OR PASTURE*

Animal	In Barn (R)	In Open Pen (R)	On Pasture (R)
Cattle	500	400	170
Sheep	400	320	240
Pigs	660	(550)**	(400)
Horses	670	(600)	(350)
Poultry	850	(780)	(730)

*From current Department of Agriculture estimates.

**Parentheses indicate no experimental data available.

GAMMA DOSE IN ROENTGENS TO REDUCE CROP YIELD BY 50 PERCENT*

Crops	YD-50 Dose
Peas, Broadbeans	less than 1000R
Rye, Barley, Onion	1000 to 2000R
Wheat, Corn, Oats, Cucumber	2000 to 4000R
Peanut, Alfalfa, Fescue, Sorghum	4000 to 6000R
Cotton, Sugar Cane, Melons, Celery	6000 to 8000R
Soybeans, Beets, Broccoli, Red Clover	8000 to 12, 000R
Rice, Turnips, Sweet Potatoes, Strawberries	12, 000 to 16, 000R
Squash	16, 000 to 24, 000R

*Based on estimates in NATO document AC/25-WP/79, **The Effects of Radioactive Fallout on Food and Agriculture,** November 1972.

EFFECTS ON THE HUMAN ECOSYSTEM

The study of the interrelationships among members of a community of animals and plants is called **ecology** and the community itself is usually referred to as an ecosystem. Today's environmentalists tend to call the human ecosystem, the "ecology." Concern has been expressed since the development of nuclear weapons that a nuclear war might have a catastrophic effect on the biological environment insofar as it affects humans. The concerns have stemmed mainly from the perceived characteristics of fallout and the radiations emanating from it.

In his novel, **On the Beach**, Neville Shute had to invent an impossible kind of fallout, one that did not settle out or undergo significant radiological decay, in order to cause the end of mankind. Others, not intending fiction, have forecast a new Ice Age or, alternatively, the melting of the polar ice caps, raising the level of the oceans to flood the eastern United States—and most of the populated part of the rest of the world. Which should occur depends on the presumed particle size and shape of that part of the fallout that is injected into the stratosphere and mesosphere (Panel 7). Particle clouds circling the earth could upset the earth's heat balance. Whether the earth would cool off or heat up would depend on whether the dust particles interfered with the sunlight striking the earth more or less than it interfered with the heat loss to outer space. Large volcanic eruptions offer the closest natural analogy. It is said that the huge eruptions of 1815, involving quantities of volcanic dust equivalent to the detonation of 50,000 MT or more, may have been responsible for an unusually cool summer the following year, some 13 degrees below normal. Indeed, the three major historic volcanic eruptions were all followed by exceptionally cold years. But only one year was affected. It has been concluded that the earth's climate is exceptionally stable despite severe temporarily imbalancing effects. Continued pressure of change over decades and centuries are required to produce an Ice Age.

Similarly, observation that insect predators, such as birds, are more vulnerable to fallout radiation has led to predictions that the insects will inherit the earth after a nuclear war. Analysis shows, however, that heavy fallout areas are rarely more than 50 to 100 miles from areas of negligible fallout. Since the population of the various species is controlled largely by food supply, there would be a rapid invasion of predators into the temporarily insect-rich areas. In sum, no nuclear attack can induce gross and permanent changes in the "balance of nature" anything like those that human civilization has already produced through agriculture and urbanization.

On the other hand, there could be ecological changes that might require governmental control action in the early postwar years. World-wide fallout could increase rainfall over normal amounts by acting as a "cloud-seeding" mechanism. This would have adverse effects in flood-plain areas but would delay the onset of fire hazard from radiation-killed trees in areas of moderate-to-heavy fallout. Failure to log dead trees (which would be useful for housing and firewood) would sooner or later result in forest fires and erosion damage. Over a period of several years, silting could destroy the usefulness of reservoirs and irrigation works. Finally, degraded sanitation and public health measures in damaged urban areas could create conditions favorable to outbreaks of disease-carrying insect and rodent populations. All these consequences are subject to human planning, intervention, and control.

IMPLAUSIBLE CATASTROPHES

1. End of all life on the planet Earth.
2. A new Ice Age.
3. Melting of the polar ice caps.
4. Insects inherit the Earth.

MORE LIKELY ECOLOGICAL CONSEQUENCES

1. Temporarily increased rainfall.
2. Fire hazard in dead pine forests.
3. Longer-term threat of increased erosion and silting.
4. Outbreaks of disease-carrying insects and rodents in damaged urban areas.

FALLOUT IN THE DAMAGED AREA

Most of the fallout from megaton-yield nuclear detonations is carried tens to hundreds of miles by the wind before it is deposited on the ground. For this reason, we have emphasized the fallout environment outside the area of blast damage and fire. Fallout from surface bursts will also occur in the direct-effects area, making firefighting, rescue, and medical aid more difficult and urgent. The next six panels describe the fallout threat in the damaged area, as defined by the Miller fallout model. Weapons test data supporting these estimates are quite limited.

Fallout does not arrive immediately in the damaged area. Particles begin to fall from the rising fireball when the rate of cloud rise decreases to less than the falling velocity of the particles. The time of arrival of first fallout from the mushroom stem is shown in the table for 1-, 5-, and 25-MT detonations.

The somewhat complex pattern below the table shows the time of arrival of close-in fallout for the example 5-MT surface burst used previously. Fallout arrives almost simultaneously at 22 minutes after burst over nearly all of the direct effects area. (For reference, the extent of 2-psi blast overpressure is shown as a dotted circle.) Thereafter, fallout progresses downwind at the assumed effective wind speed of 15 miles per hour, reaching a distance of about 16 miles at one hour after detonation. For other wind speeds, the distances shown would obviously be different.

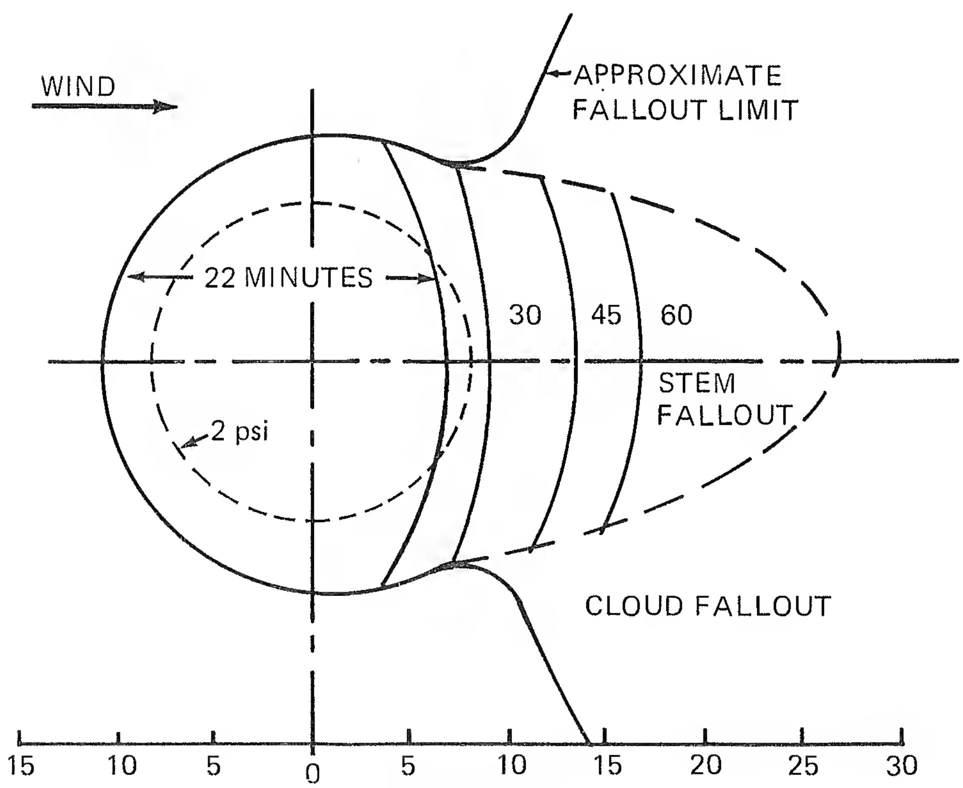
One might ask how it could be that fallout would not arrive at 16 miles downwind until one hour after detonation when, in Panel 9, we saw that fallout arrived 30 miles downwind at 45 minutes after burst. The reason is that the point at 30 miles, shown by a black dot, is in the cloud fallout region, not the stem fallout region. In the upwind portion of the cloud fallout region, fallout from the bottom of the cloud arrives before that from the main portion of the cloud. The earliest arrival of cloud fallout is beyond 30 miles and arrival times increase toward ground zero. Fallout arrival at 25 miles is later than at 30 miles, increasing to about one hour inside 20 miles where cloud and stem fallout arrive almost simultaneously. Therefore, stem fallout arrival times are not shown beyond one hour.

EARLIEST FALLOUT ARRIVAL

Weapon Yield	Fallout Arrival Time
1 MT	16 Minutes
5 MT	22 Minutes
25 MT	30 Minutes

FALLOUT ARRIVAL FOR 5 MT BURST

(15 MPH WIND SPEED)



PANEL 29

EARLY OPERATIONAL DOSES

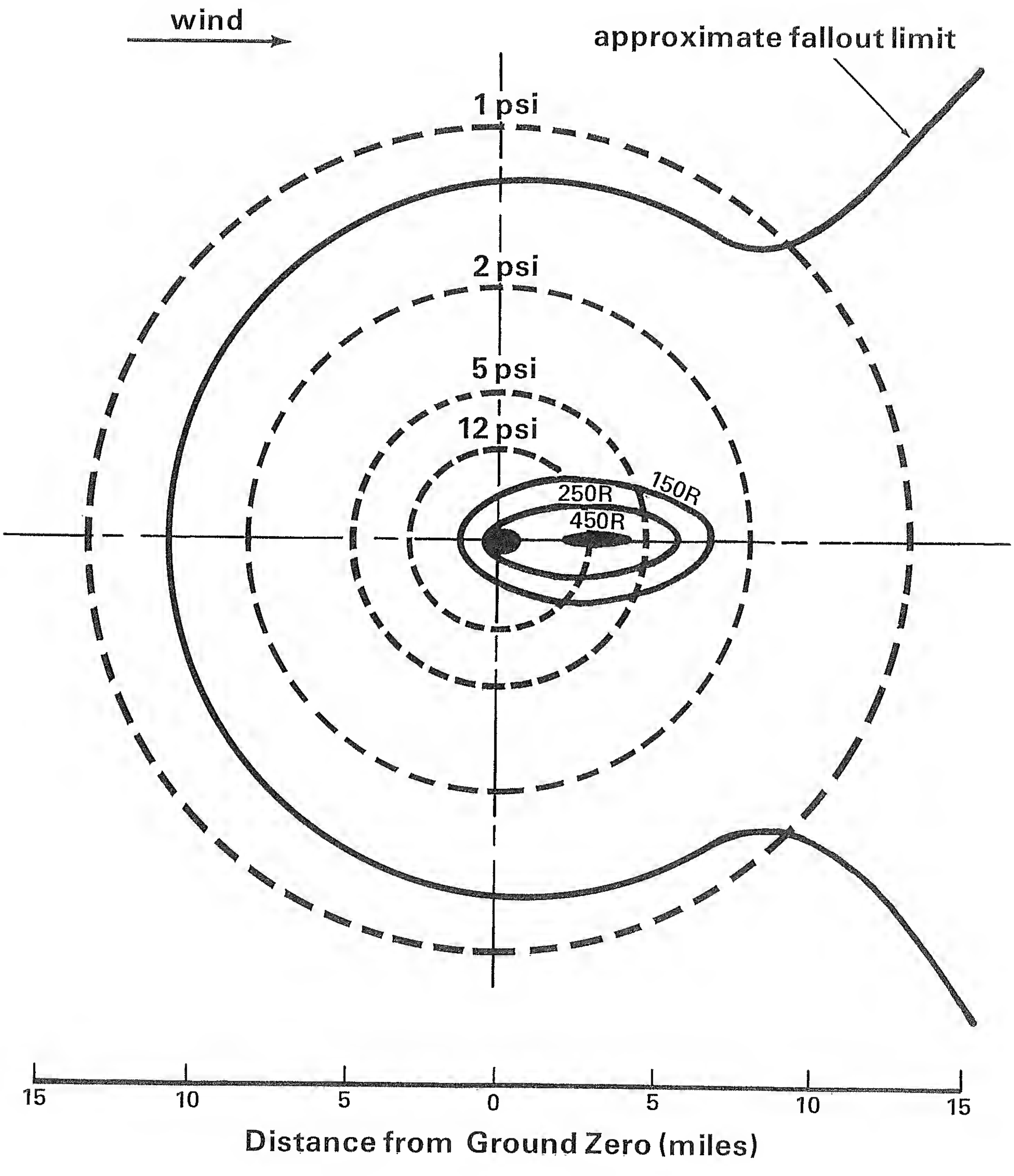
Although fallout will arrive in the damaged area within 15 to 30 minutes after detonation, fallout radiation exposures during the critical first hour will generally be nominal. The region affected by the doses defined in the Dose Penalty Table of Panel 15 is shown here. This region is confined to a small downwind area in the moderate and severe damage areas. There is a small area astride the 12-psi circle where exposures in the first hour would be in excess of 450R. Practically all of the area where suppression of smouldering ignitions, fire-fighting, rescue, and medical aid would be urgent tasks would experience outside doses of less than 150R during the first hour.

The doses shown are not those that would be received over a smooth, infinite plane. As we saw in Panel 16, exposures under actual operating conditions would be lower than the smooth, infinite-plane case because real surfaces are rough and of limited extent. Debris caused by blast damage would make most of the damaged area quite "rough." How "rough" these areas might be can be appreciated by reviewing Panels 35 and 36 of Chapter 2.

For this example, it has been assumed that the "real world" exposures would be about one-third those predicted for the smooth, infinite-plane situation. This is probably a conservative estimate of the effect of blast damage, and actual exposures would likely be even lower. Radiation exposures would vary even more widely than suggested by Panel 16. To aid in control of such exposures, at least one member of each emergency team should be equipped with a dosimeter.

One additional point to be considered is that, although gamma radiation exposures might be nominal during the first hour, fallout would be occurring during most of this period. Emergency teams should be dressed to avoid accumulation of fallout particles on the skin. A "Man-from-Mars" suit is not necessary. A coat with hood or hat and gloves are desirable. The usual fireman's "running gear" is excellent for the purpose.

DOSE DURING THE FIRST HOUR
(5MT SURFACE BURST -15 MPH WIND)



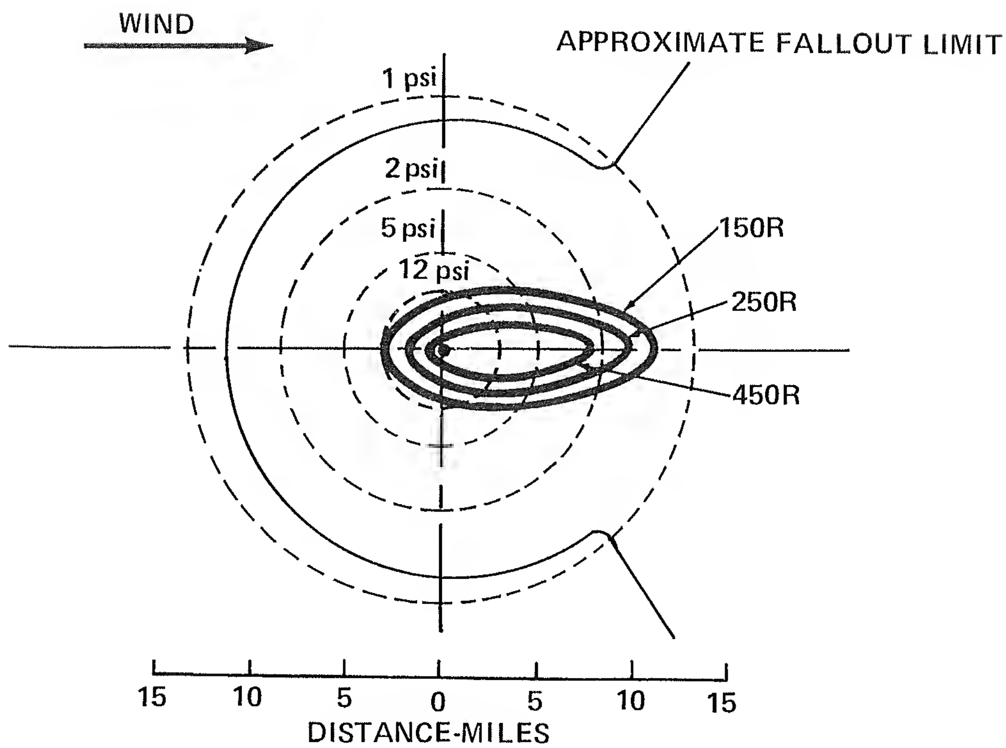
LATER OPERATIONAL DOSES

Urgent tasks of fire defense, rescue, medical aid, and remedial movement of people from threatened shelters may require continued operations beyond the first hour after a detonation. Shown here are the areas in which 150R, 250R, and 450R doses might be expected during the first two hours (upper sketch) and first four hours (lower sketch). The assumption as to the roughness of the debris-strewn area is the same as in the previous panel.

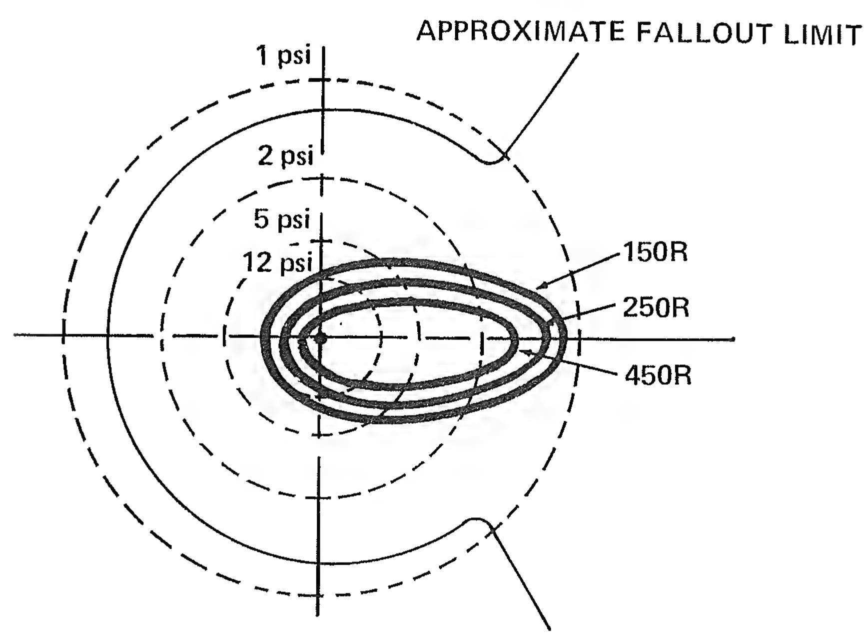
At two hours, the area enclosed by the 450R dose contour extends from about 1 mile upwind to about 8½ miles downwind and is about 4 miles wide at its widest. By the end of four hours, this area extends from 1½ miles upwind to 10 miles downwind and is 5 miles wide. As can be seen, doses above 150R are likely only in the downwind sector of the damaged area and affect less than one-third of the potential fire area.

In contrast to the situation in the cloud fallout area further downwind, the dose rate in the stem fallout area will peak well before the cessation of fallout. This is because of the rapid decay of radioactivity at early times. The dose rate can be expected to peak within the first hour throughout most of the damaged area. Only a small part of the subsequent dose is received during the "buildup period." Hence, the observed peak dose rate can be used to guide emergency operations. For example, where the dose rate peaks at, say, 125 R/hr, the anticipated dose in the first two to four hours is predicted to be about 125R. Similarly, if the CD V-715 goes off-scale on the high range (greater than 500 R/hr), potentially lethal outside exposures are to be anticipated. Since the direction of down-wind fallout may not be related to the observed surface winds, use of radiation measurements is to be preferred in operational planning.

DOSE DURING FIRST TWO HOURS
(5 MT SURFACE BURST-15 MPH WIND)



DOSE DURING FIRST FOUR HOURS



EFFECT OF FIRES ON FALLOUT DEPOSITION

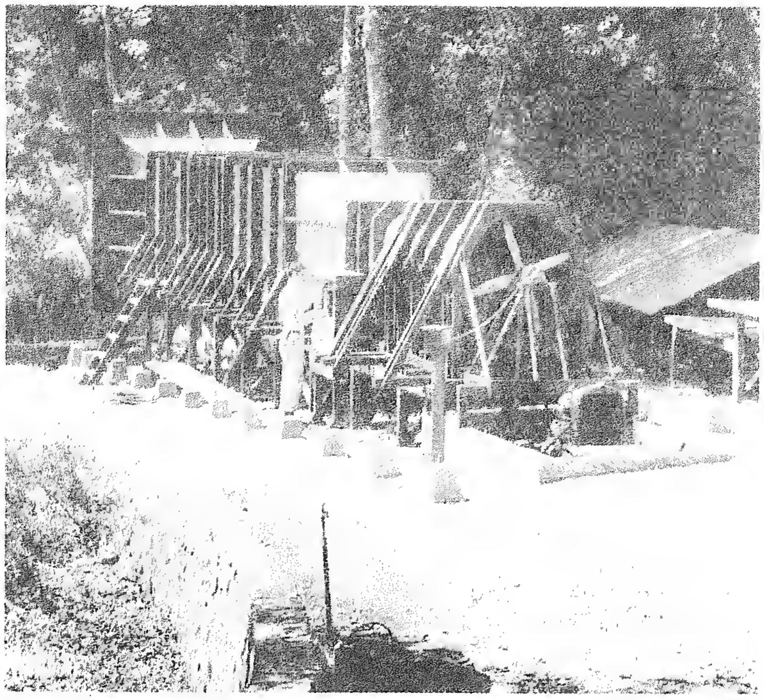
In Chapter 3, the fire environment in the damaged area was described. Mass fires are marked by "in-rush" winds and a rising "convection column" above the fires. Theoretical analyses of convection columns above large-scale fires indicate that the updraft from even moderate rates of heat output exceeds the falling velocities of most fallout particles. It would appear, then, that convection columns induced by fires set by the detonation could have an effect on the fallout pattern.

A time lapse occurs between the time of ignitions and the time when massive fires can be burning. Experience from World War II incendiary raids indicates this time period may vary from 25 to 45 minutes. The effect of the nuclear blast wave in suppressing ignitions to a smouldering condition would increase this time delay substantially. Thus, it is unlikely that the fires resulting from a megaton-yield surface burst would alter significantly the deposition of stem fallout in the damaged area.

Analyses and experiments have been done to assess the effect of well-established fires on fallout deposition from the cloud or from later fallout from upwind detonations. The main experiments were conducted in the low-velocity wind tunnel shown here. Gas burners were used to simulate the fire area and simulated fallout was introduced upwind of the fire near the top of the wind tunnel. As predicted by theory, the fire updraft buoyed up the fallout, causing it to fall much further downwind than otherwise would be the case. There was also much lateral dispersion of the fallout so the effect would be to lower markedly the high dose rates in the downwind area and increase somewhat the lower dose rates over a much larger area.

Other experiments conducted in the mid-1950s showed that rapidly burning fires in already contaminated areas as small as one tenth of an acre resulted in removal of perhaps a third of the deposited fallout, and the removed material was dispersed so that there was no significant concentration in any other region. This process may have some effect in further reducing radiation hazards during firefighting operations.

LOW-VELOCITY WIND TUNNEL USED IN FIRE-FALLOUT EXPERIMENTS*



* From Broido, A., and McMasters, A.W., **The Influence of a Fire-Induced Convection Column on Radiological Fallout Patterns**, California Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, February 1959. (Library of Congress PB 149923)

PANEL 32

EFFECT OF DAMAGE ON FALLOUT PROTECTION

The fallout protection afforded by buildings (Panel 18) is estimated on the basis that the roof and surrounding ground areas are uniformly contaminated with fallout and that fallout does not lodge on the sides of the buildings nor do fallout particles penetrate into the interior of the building. In effect, the calculation is made as if the fallout fell vertically onto the surfaces below. In the real world, winds or breezes are blowing near the ground most of the time. If windows were broken or walls blown in, some fallout could penetrate into the interior of buildings.

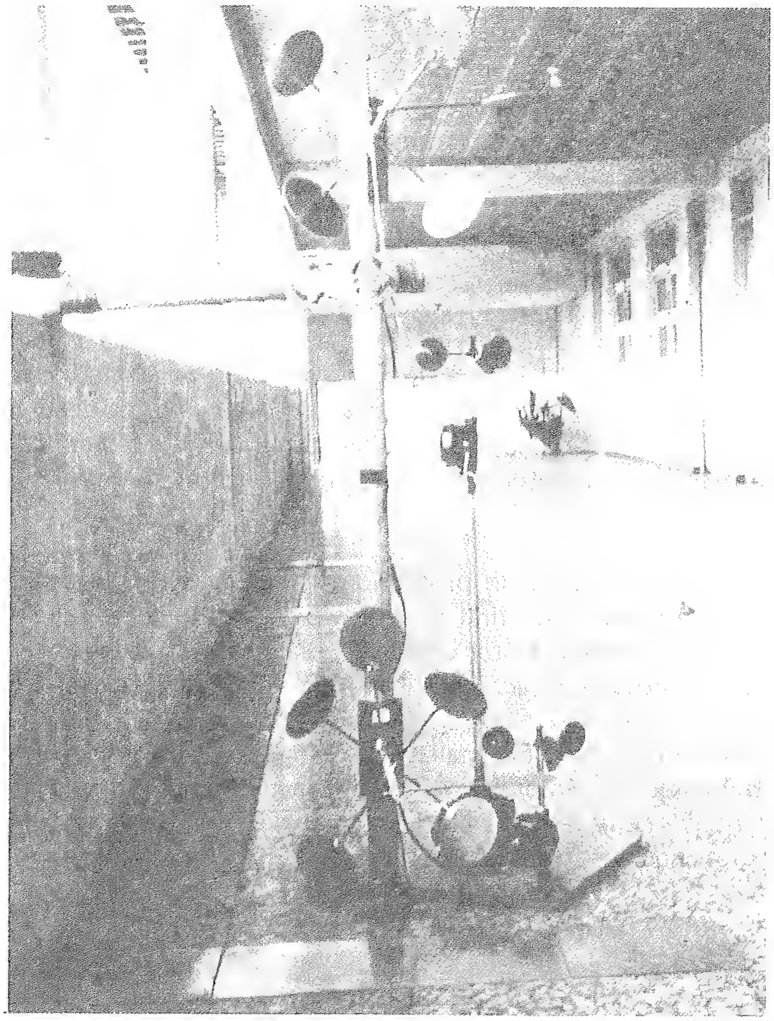
A number of calculations have been made of the effect of "fallout ingress" on the protection afforded by buildings. These estimates have been necessarily highly idealized and are not very useful. The small amount of experimental evidence available does indicate, however, that large reductions in fallout protection are not to be expected in most instances.

The best evidence comes from the volcano fallout in Costa Rica described in Panel 12. Shown here is a fallout situation where most of the wall is open. Visible fallout is concentrated in a band about 20 inches wide below the sill. (The devices shown are for collecting fallout and measuring air movement.) Measurements indicated that the deposition near the sill was about 5 percent of that on the ground in the open and about 1 percent elsewhere in the corridor. Other measurements near smaller open windows indicated deposition near the windows of about 1 percent of the exterior amounts. Calculation of the effect of this amount of ingress on the mid-floors of tall buildings indicate a reduction of about 5 percent in the protection factor (e.g., 38 PF rather than 40 PF). Measurements under covered walkways where both sides were completely open indicated that as much as one-tenth of the outside deposit level could be deposited. Thus, where walls are completely blown in as shown in the upper sketch of Panel 14 in Chapter 2, the protection factor in the middle floors could be reduced by perhaps 10 percent or more (e.g., 35 PF rather than 40 PF).

The deposition of building debris on the floor above basements would tend to increase the protection below in most cases.

The most serious degradation of fallout protection due to blast damage would occur in residential basements and the basements of other lightly constructed buildings under the circumstance where the building is blown clear of the basement (lower sketch in Panel 12 of Chapter 2). Fallout would be deposited in the basement, reducing the protection factor from 20 to 40 down to about 4 or 5. It would be necessary for basement occupants to prop sections of flooring or walls against the basement wall, lean-to fashion, and to cover the lean-to with nearby pieces of masonry for fallout protection. This need is another reason why it may be desirable to plan for group occupancy of residential basements in urban areas rather than single families.

OPEN CORRRIDOR ON THIRD FLOOR OF SCHOOL CONTAMINATED BY FALLOUT-LIKE VOLCANIC DEPOSIT IN COSTA RICA*



*From Clark, D.E., Jr., and Sartor, J.D., **Operation Ceniza-Arena: Techniques for the Measurement of Deposition and Redistribution of Fallout Around Structures**, Stanford Research Institute Project No. MU-5779, December 1966. (AD 647 242)

PANEL 33

WHAT ABOUT HILLS?

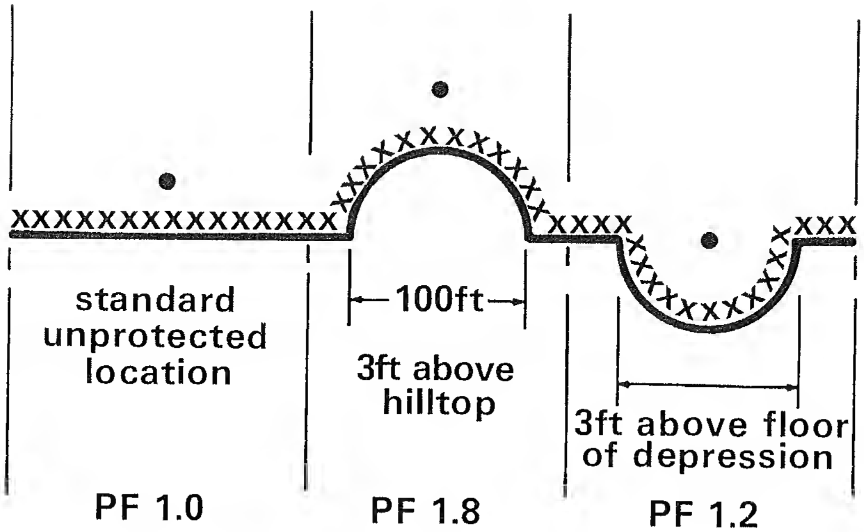
Protection factor calculations assume that fallout is deposited on smooth plane surfaces. In Panel 16, the effect of the roughness of real surfaces was discussed, but again in terms of level terrain. The question might be raised as to the effect of prominent terrain features, such as hills and valleys.

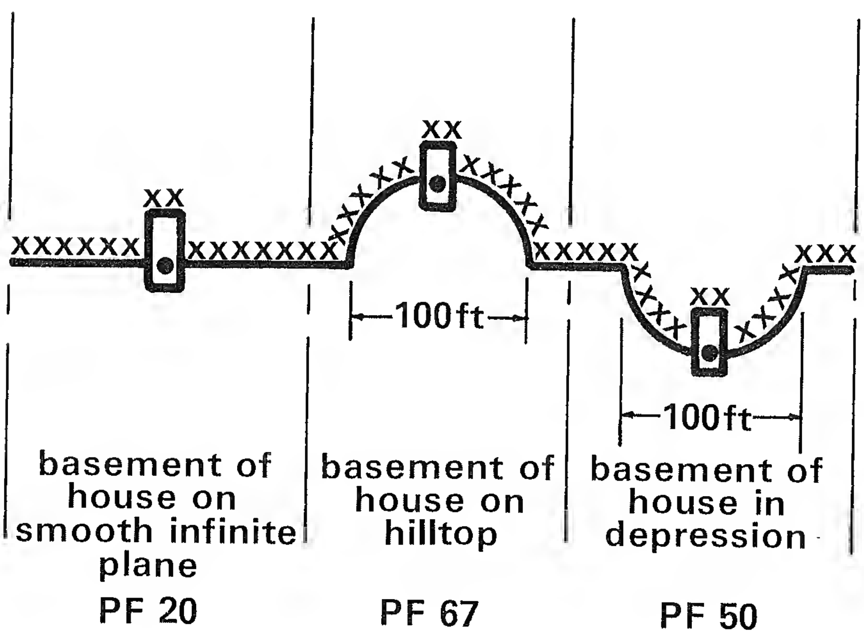
The upper sketches show the protection afforded a person standing in the open on smooth surfaces. When the surface is level, we have the standard unprotected location for which the protection factor is 1. If the person were on top of a small, steep hill that falls away in all directions (the example shown here is a hemisphere with a diameter of 100 feet), the PF is increased to nearly 2 because the hill hides much of the fallout beyond the immediate area. The protection factor for a small, steep depression is not much improved over the infinite-plane situation.

The effect of terrain features on protection in basements is much more marked, as shown in the lower sketches. The first situation shows a home basement on a smooth, infinite plane having a protection factor of 20. The same house on top of a small, steep hill would have a basement protection factor of nearly 70. Many rural houses are built on hills.

The same house on the floor of a small, steep depression would also have a substantially increased basement protection factor. However, not many homes are built in such locations. In general, undulations of the terrain tend to restrict the area of fallout that can contribute to radiation exposure and thus improve protection.

EFFECT OF TERRAIN FEATURES





A NOTE ON DECONTAMINATION

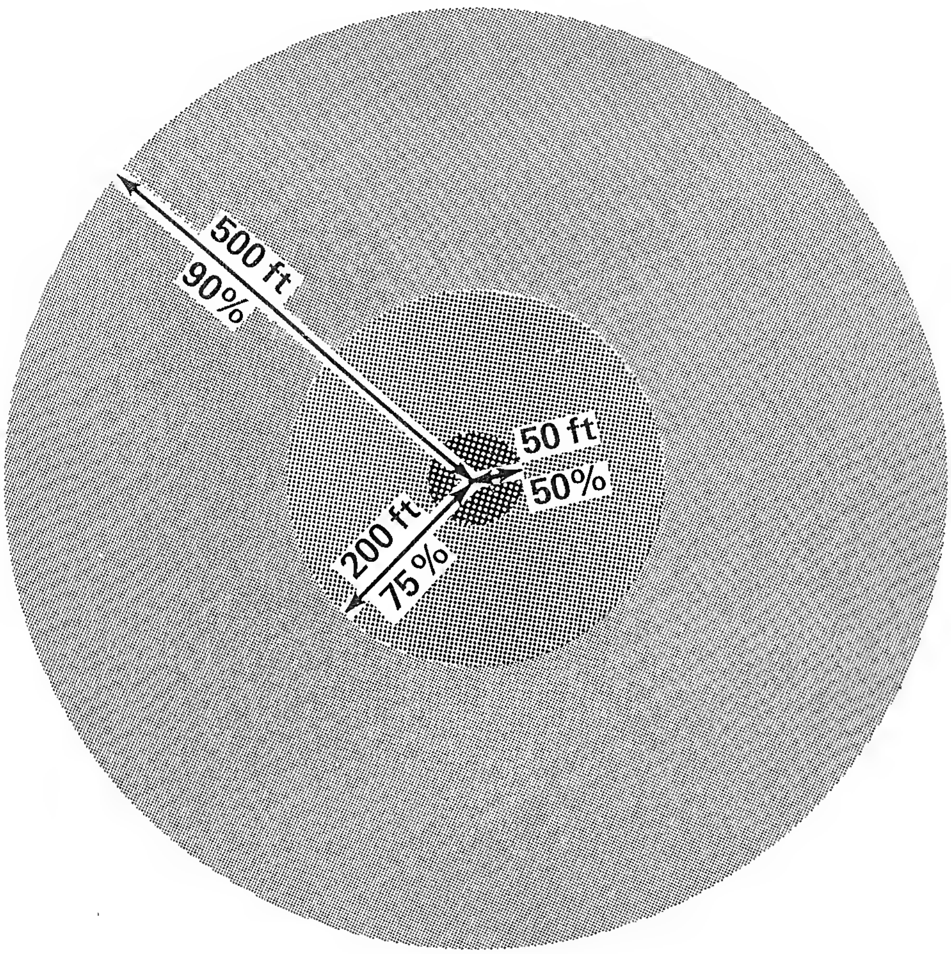
Surfaces on which fallout particles have fallen are called **contaminated** surfaces. Being sand-like material, fallout can be cleaned from most surfaces by readily available means. The process of removing fallout particles from exposed surfaces and disposing them where they cannot harm people is called **radiological decontamination**. Paved areas can be decontaminated with firehoses, street flushers, or with street sweepers. Roofs can be decontaminated with firehoses. Unpaved areas can be decontaminated by scraping off or plowing under the top layer of soil.

As shown in this sketch, half of the radiation received at a point 3 feet above a large, smooth, unbroken surface comes from fallout within 50 feet. On rough surfaces, the area contributing half the exposure is much less. In an area covered with 6 inches of debris, a depth indicated in Chapter 2 as quite common, half the radiation comes from fallout within about 10 feet.

The sketch shows that three-quarters of the radiation comes from fallout within 200 feet on smooth surfaces (100 feet or less on rough or debris-strewn surfaces). But at least 10 percent of the exposure comes from fallout radiation originating many hundreds of feet away. This suggests that, if large reductions of exposure are desired, not only must the work or living area be decontaminated but also a "buffer zone" around it to a distance of several hundred feet in most instances.

For this reason, decontamination as a measure to improve the fallout protection of people in shelter is not generally practical except, possibly, for the sweeping up of visible fallout near broken windows or near entrances to a shelter area. Decontamination can be important, however, in speeding postattack recovery in fallout areas. Hence, decontamination is covered in more detail in Chapter 8.

DOSE CONTRIBUTION vs DISTANCE



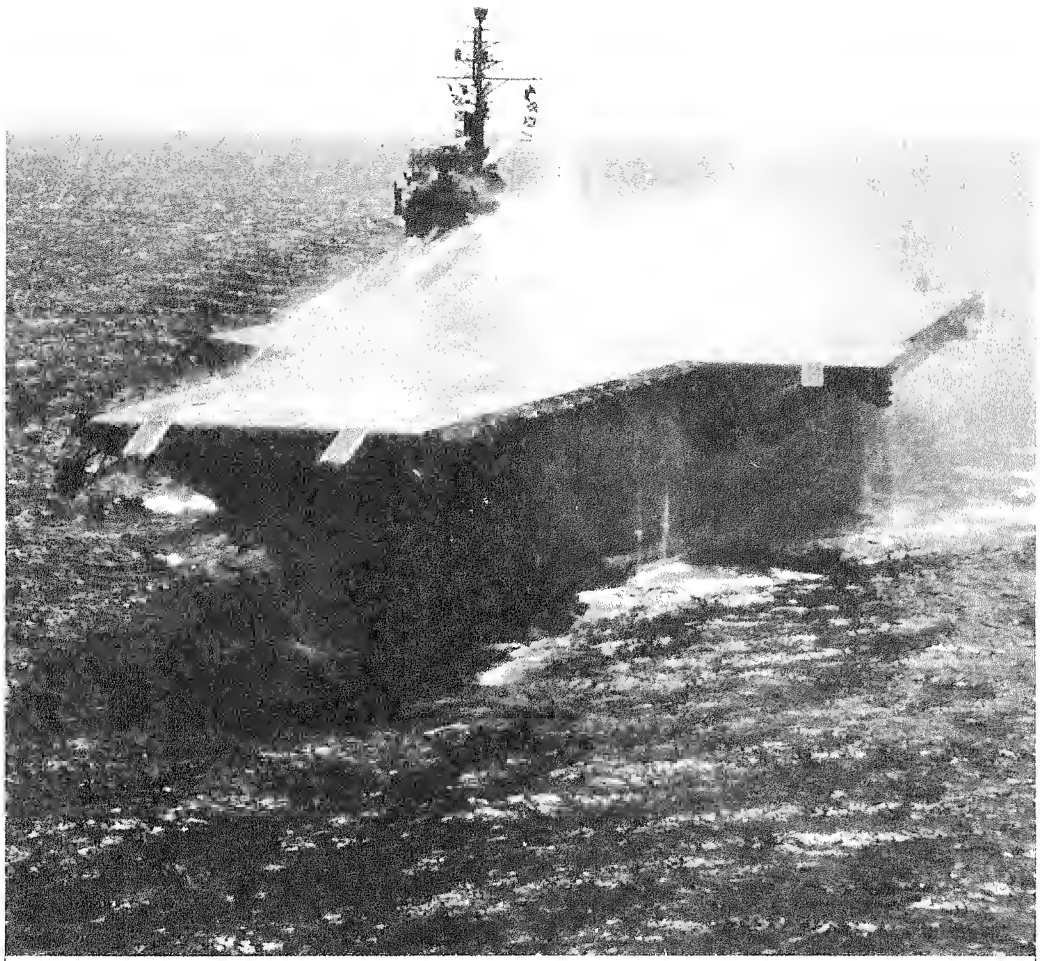
PANEL 35

WHAT ABOUT BOATS?

The fact that a large part of the radiation from fallout comes from contaminated areas a considerable distance away has suggested that boats and ships located on bodies of water (lakes, rivers, and bays) might provide good fallout protection. Fallout particles will settle rather quickly to the bottom. Three to five feet of water will provide ample shielding from this fallout. Thus, if a boat is anchored or lying at least several hundred feet offshore, nearly all of the radiation exposure will come from fallout actually deposited on the boat. Most fishing and pleasure boats are quite small, and the protection factor from being on the water would be about 4 or 5, better than in a house but not as good as most home basements.

The protection can be greatly improved by rigging a tarpaulin or awning over cockpit areas and shaking or sluicing the canvas to dislodge the fallout particles when visible deposits appear. Exposed decks can also be sluiced by hose or bucket. Thus, a combination of lying offshore and early decontamination can generally result in an equivalent protection factor of 20 to 40. If no better fallout protection is available, boats may be considered in localities where they are plentiful.

Ships may also be useful in many circumstances. They can carry large numbers of people. Because they are larger than boats, the radiation levels from fallout deposited on the decks more nearly approaches the level that would occur on shore. The steel construction will offer significant shielding but prompt decontamination is also necessary to achieve a reasonable amount of fallout protection. The topside areas of ships are readily flushed off. Most naval ships and some merchant ships have washdown equipment to accomplish rapid decontamination. A washdown system in action is shown here.



PHOTOGRAPH OF USS KITTY HAWK UNDER WASHDOWN
(Courtesy of Office of Chief of Naval Operations)

PANEL 36

FACTS ABOUT RADIATION AND FALLOUT

During the average lifetime, every person receives about 10 Roentgens of ionizing radiation from nature and about an equal amount additionally from dental and chest X-rays and even the luminous dials of wrist watches. Yet radiation effects and fallout remain mysterious and misunderstood threats to both the average citizen and government employee. Emergency planning should include informing the public on the basic facts shown here if an unwarranted paralysis of action during a fallout emergency is to be avoided. The basis for these statements is contained in the panels of this chapter and those of Chapter 5.

SOME BASIC FACTS

1. Everyone receives some radiation exposure in peacetime. It is when large doses are absorbed in a short period that sickness or death results.

2. Radiation sickness is neither contagious nor infectious. But people made sick by radiation are temporarily more susceptible to infection.

3. Radiation exposures that cause sickness are much lower than those that cause death. Being sick does NOT indicate that one is necessarily going to die.

4. Fallout radiation cannot make anything radioactive. Fallout itself consists of sand-like particles too large to be inhaled.

5. Dangerous amounts of fallout can generally be seen but special instruments are needed to measure the danger of radiation exposure.

6. Radiation exposure can be kept below sickness levels by using good fallout shelter; by delaying outside activities until decay has reduced the exposure rate; and by limiting the time of exposure on urgent tasks.

7. No one should thirst or starve for fear of contaminated water or food. Illness can be caused as readily by malnutrition and poor sanitation as by radiation injury.

SUGGESTED ADDITIONAL READING

The following sources provide additional background on the material in this chapter:

Effects of Nuclear Weapons, Revised Edition 1964, Glasstone, S., (editor), Chapters 1, 2, 6, 9, 10, and 11, Superintendent of Documents, GPO.

National Committee on Radiation Protection, **Exposure to Radiation in an Emergency**, Report No. 29, January 1962.

Miller, C.F., **Fallout and Radiological Countermeasures, Volumes I and II**, Stanford Research Institute, January 1963. (Vol. I—AD 410 522, Vol. II—AD 410 521)

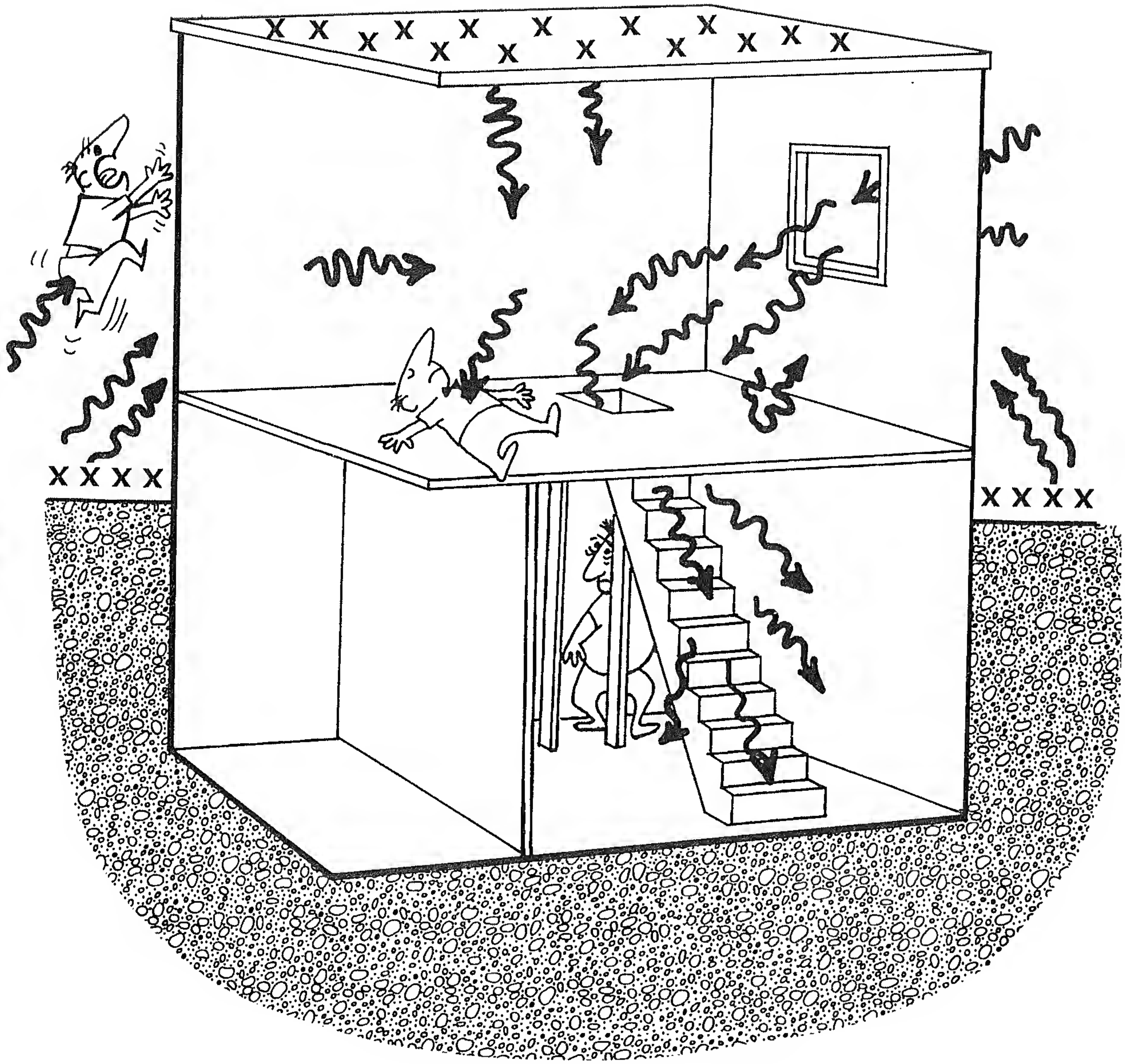
Casarett, A.P., **Radiation Biology**, Prentice-Hall, 1968.

Upton, A.C., **Radiation Injury: Effects, Principles, and Perspectives**, University of Chicago Press, 1969.

Bensen, D.W., and Sparrow, A.H.,(editors), **Survival of Food Crops and Livestock in the Event of Nuclear War**, No. 24 of AEC Symposium Series, CONF-700909, December 1971.

Radiological Defense Textbook, SM-11.22.2, Office of Civil Defense, June 1968.

Radiological Health Handbook, U.S. Department of Health, Education and Welfare, Public Health Service, Rockville, Maryland 20852, January 1970.



PANEL 38

CPG 2-1A8
June 1973

DCPA ATTACK ENVIRONMENT MANUAL

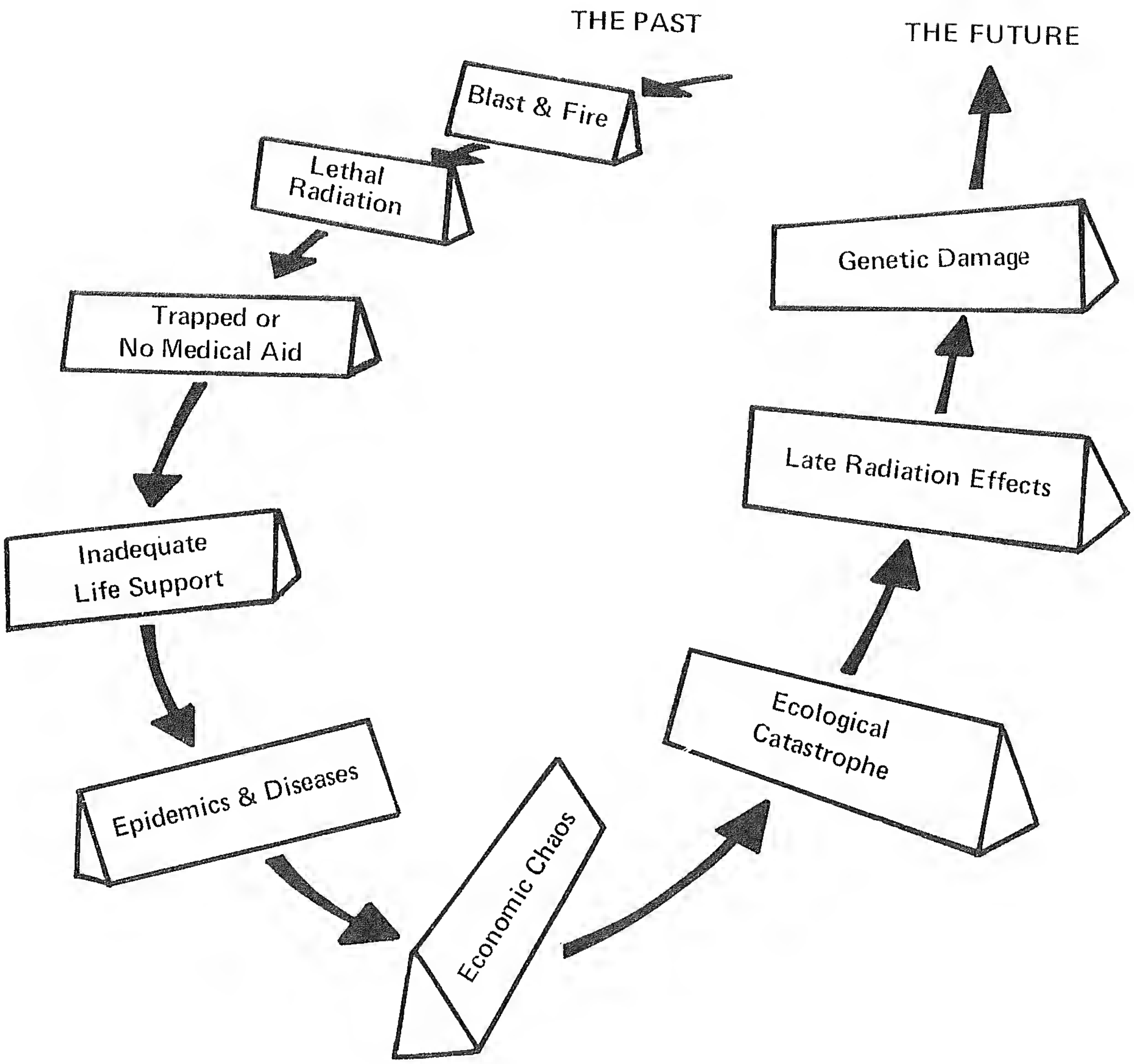
CHAPTER 8

WHAT THE PLANNER NEEDS TO KNOW ABOUT
THE POST-SHELTER ENVIRONMENT

DEFENSE CIVIL PREPAREDNESS AGENCY
DEPARTMENT OF DEFENSE

JUNE 1973

NINE BARRIERS TO WELL-BEING*



*Based on Greene, J.C., **The Case for Civil Defense**, DCPA Research Report No. 16, 1972 (AD 758 452).

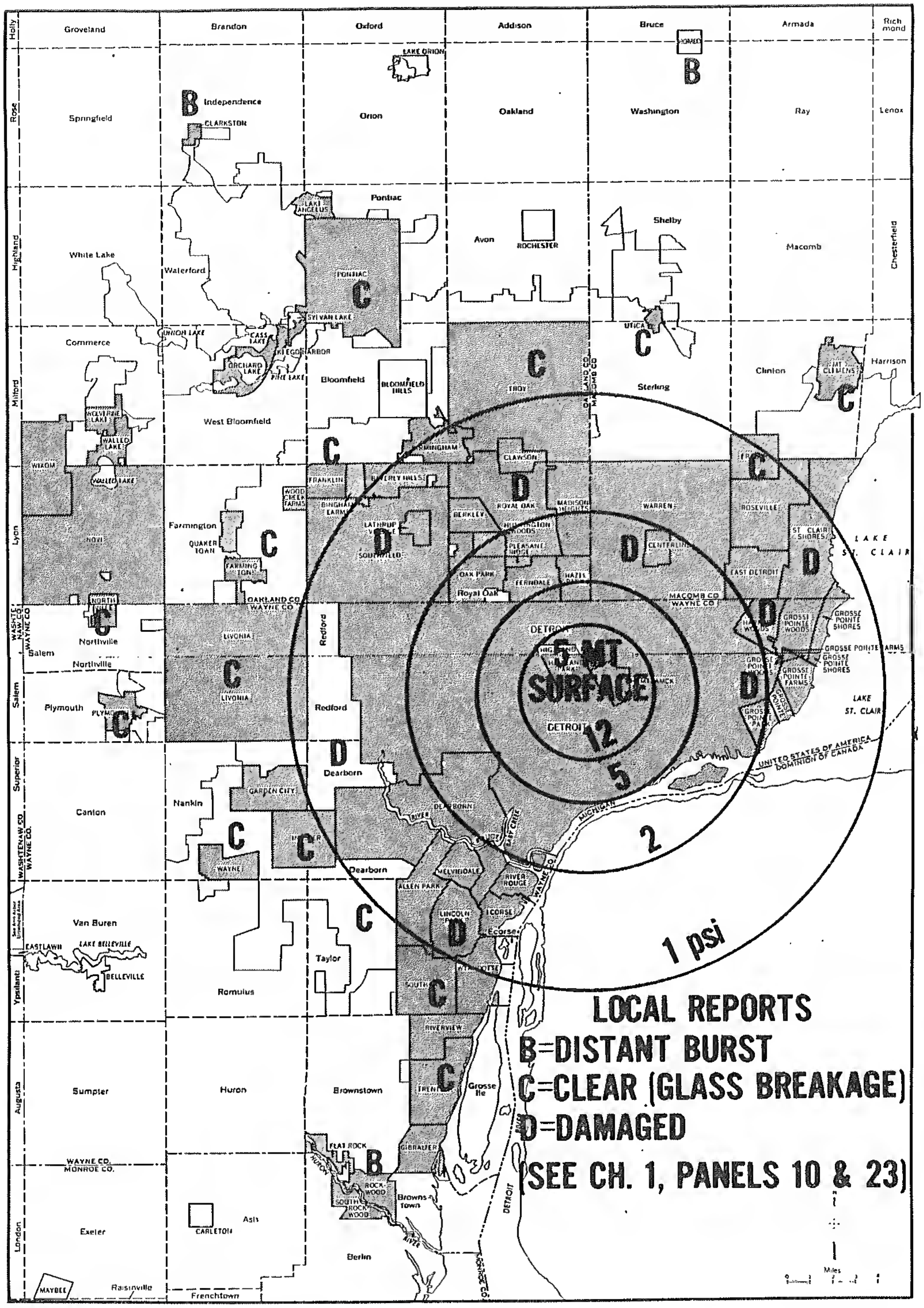
PANEL 1

PRIORITY NEEDS*

1. People would need leadership.
2. People would need information.
3. People would need reassurance.
4. People would need instructions.

*From Allnutt, Bruce C., **A Study of Consensus on Psychological Factors Related to Recovery from Nuclear Attack**, Human Sciences Research, Inc., May 1971. (AD 730 360)

DETROIT URBANIZED AREA



PANEL 4

THE FALLOUT CONSTRAINT

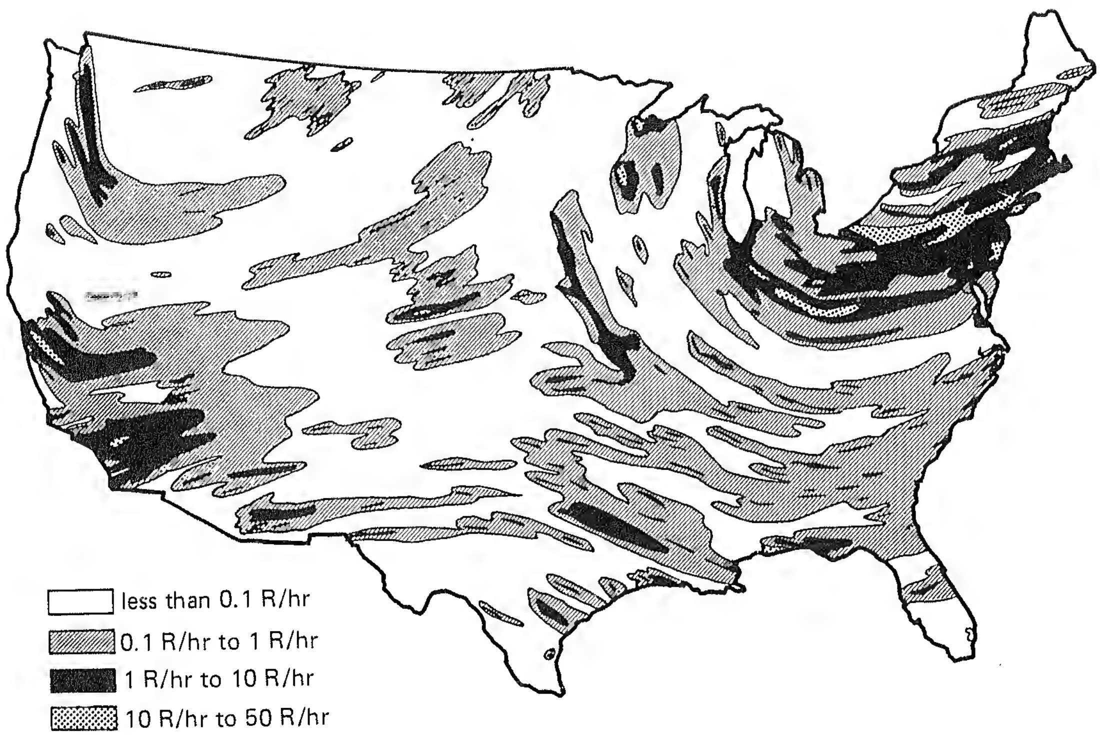
Gamma radiation from fallout is the attack effect that may persist in the post-shelter environment in amounts sufficient to cause injury or death. Studies of possible attacks in which fallout-producing surface bursts are assumed to occur indicate that, by one week after the last detonation, no part of the U.S. would be in a HIRAD situation (dose rate in excess of 50 R/hr).

The example fallout map shown here indicates the areas of the United States in which dose rates at the end of the first week could restrict post-shelter operations, as estimated by the Miller fallout model for the winds of a particular Spring day. An attack is assumed in which a portion of the weapons, amounting to about 2500 megatons, is detonated on the surface to cause fallout. In the clear areas, the dose rates at the end of the first week are estimated to be less than 0.1 R/hr (100 mR/hr). The dose rates in the lined area would range from 0.1 R/hr to 1R/hr. The black areas would have dose rates between 1R/hr and 10 R/hr. There are several stippled areas on the map where the one-week dose rates would be over 10 R/hr.

Time would further reduce the fallout radiation hazard. Using the 7-10 Rule discussed in Chapter 6, seven weeks after the attack the lined areas would become clear, the black areas would become lined areas, and the stippled areas would be black areas. To achieve a further factor-of-10 reduction would require, according to the rule, another seven-fold passage of time (49 weeks, or nearly one year after attack). Actually, increasingly rapid decay after six months and the effects of weathering would leave few, if any, areas outside the bomb craters above 100 mR/hr at year's end.

If the people are instructed and guided to limit exposures so as to avoid post-shelter radiation sickness, the principal effect of fallout radiation during the early months would be to delay the accomplishment of recovery activities. Delay would occur for several reasons. Recovery workers would need to restrict their exposure outside shelter to a shorter work-week in most cases. Survivors most able to participate in the recovery work force would be those in the best fallout shelters or those coming from areas experiencing little fallout, there by limiting the size of the work force. Survivors manifesting symptoms of radiation sicknes during the first week would have to remain in shelter or be transported to less-contaminate areas. It can be seen from the map that the distances to be traveled from heavy fallout are to areas of much lower hazard are not great in most instances.

EXAMPLE FALLOUT MAP
(DOSE RATES AT ONE WEEK)



PANEL 5

DECONTAMINATION

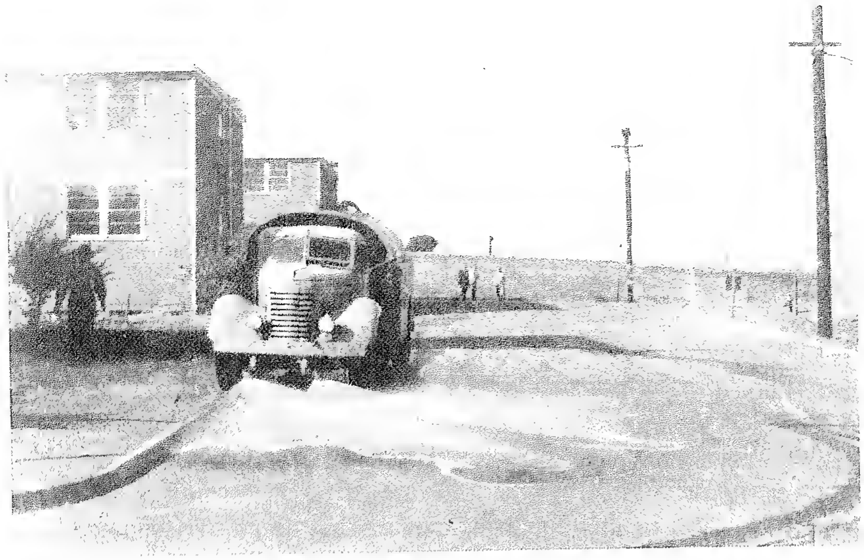
As noted in Chapter 6, the delays caused by fallout radiation can be reduced greatly by decontamination, a process in which the deposited fallout is removed from surfaces and placed where it can no longer irradiate people. Thus, if 90 percent of the fallout material affecting a workplace could be removed in the first few weeks, a situation would be created that would not occur otherwise until many months later. Halving the dose rate would permit recovery workers to work twice as long as would otherwise be the case.

Outside damaged areas, decontamination can be accomplished using a variety of common methods. Flushing fallout particles from roofs and paved surfaces and into the storm drains by means of a firehose has been found to remove over 90 percent of the fallout material. An hour's work by three men with a firehose will clean 1800 square feet of roof or 15,000 square feet of paved area. Motorized street flushers and street sweepers are more effective on paved areas and three to five times faster. Open ground areas can be scraped by earth-moving equipment: scrapers, graders, or bulldozers. These methods typically remove a slice of native soil amounting to several hundred times as much as the thin coating of fallout removed with it. The scrapings must be dumped at a remote corner of the cleared area. With room to maneuver, these methods are as effective as the paved area methods and almost as fast.

In damaged areas, widespread debris will complicate the decontamination process. If water pressure has been restored, the preferred decontamination procedure is to fire-hose an area 30 to 50 feet in radius around the debris-clearing equipment, flushing the exposed fallout down into or under the debris piles. Then, the street or area can be cleared of debris, and the remaining fallout in the cleared area can be flushed into the drains. Without water, debris removal must occur first, followed by motorized sweeping or vacuuming of the fallout.

Because of the specialized equipment and operator skills required by most decontamination techniques, widespread decontamination of whole cities does not appear practical during the first month or so. Decontamination will be useful to permit key utility plants, staging areas, and supply warehouses to be operated safely in the first weeks after attack. Later, a large part of the population can be usefully employed in mass clean-up efforts, using household brooms, garden hoses, and shovels. Calculations have shown that such efforts can result in significant reductions in population exposure to radiation over the long term.

SOME DECONTAINATION OPERATIONS*



Decontaininating with a street flusher

Removing fallout from an unpaved area.

*From Owen, W.L., and Sartor, J.D., **Radiological Recovery of Land Target Components - Complex III**, U.S. Naval Radiological Defense Laboratory, November 1963 (AD 433 141).

PANEL 6

NATIONAL FOOD SUPPLY*

	Days Supply**
Farm Crops in the Field (Grains only on July 1st)	1163
Grain Stocks	
Food Processors and Private Storage	457
Government (CCC) Inventory	103
Farm Animals (Cattle, Hogs, Poultry)	105
Food Processors and Interstate Warehouses	45
Local "Secondary" Resources of Food (Wholesalers, Retailers, and Households)	25
Grand Total	1898***

*Based on 1969 data in A.F. Shinn, **Vulnerability of the U.S. Food Supply and Food Distribution to Nuclear Attack**, Oak Ridge National Laboratory, 1969.

**Assumes 3000 calories daily for 203 million people.

***Neglecting crops in the field and farm animals leaves 630 days of supply or nearly two years of food, mostly grain.

PANEL 8

EMERGENCY HOUSING

To the extent that people have survived the attack environment, both direct effects and fallout, the areas where they were sheltered may continue to offer adequate protection against the elements. We saw in Chapter 2 that people can survive blast and fire effects better than houses. Thus, millions of homeless survivors can be expected after a nuclear attack. Some portion of these will have been driven from untenable shelters during the emergency period and will have had to seek shelter elsewhere. Nonetheless, providing of emergency housing is unlikely to be as urgent in the post-shelter environment as would be assuring the survivors that water will be available for drinking and personal hygiene and that no family or small group need forage on their own for the next meal.

Post-shelter emergency housing will be important to plan for not only for health reasons but also for morale purposes. Just as the opportunity to take a bath is likely to mark an early postattack milestone, so will the opportunity to sleep once more in a bed in the privacy of one or more rooms assigned to a family. As shown in this chart, such relative comfort is likely through use of only surviving housing units because Americans presently enjoy housing accommodations that are quite roomy compared to those in many other countries of the world.

A measure of adequacy in emergency housing would likely be the criterion of 40 square feet per person used following peacetime disasters. This is four times the DCPA shelter space allotment but far short of the space normally available in U.S. housing units, the majority of which have five or more rooms. In areas nearby nuclear detonations, a major repair task will be to cover in various ways the window openings that have been blown out by the blast wave. In fallout areas, occupancy of emergency housing during the first month may require converting multi-story office buildings into dormitories by bringing beds from the less protective residences or decontamination and intensive use of selected multi-unit dwellings until the rest of the housing can be safely used. In any event, occupancy of emergency housing will entail the restoration of electric power, water, and the availability of fuel for heating and cooking.

Ultimately, the housing destroyed in the attack will have to be replaced to the extent the survivors require it. A standard of housing approaching the preattack situation is consistent with recovery goals and with the need to assure the public of the return of private property to its rightful owners at the earliest possible time and the replacement of losses through some system of loss sharing. This is a longer-term matter that will be planned for at the Federal level in conjunction with recovery of industrial production.

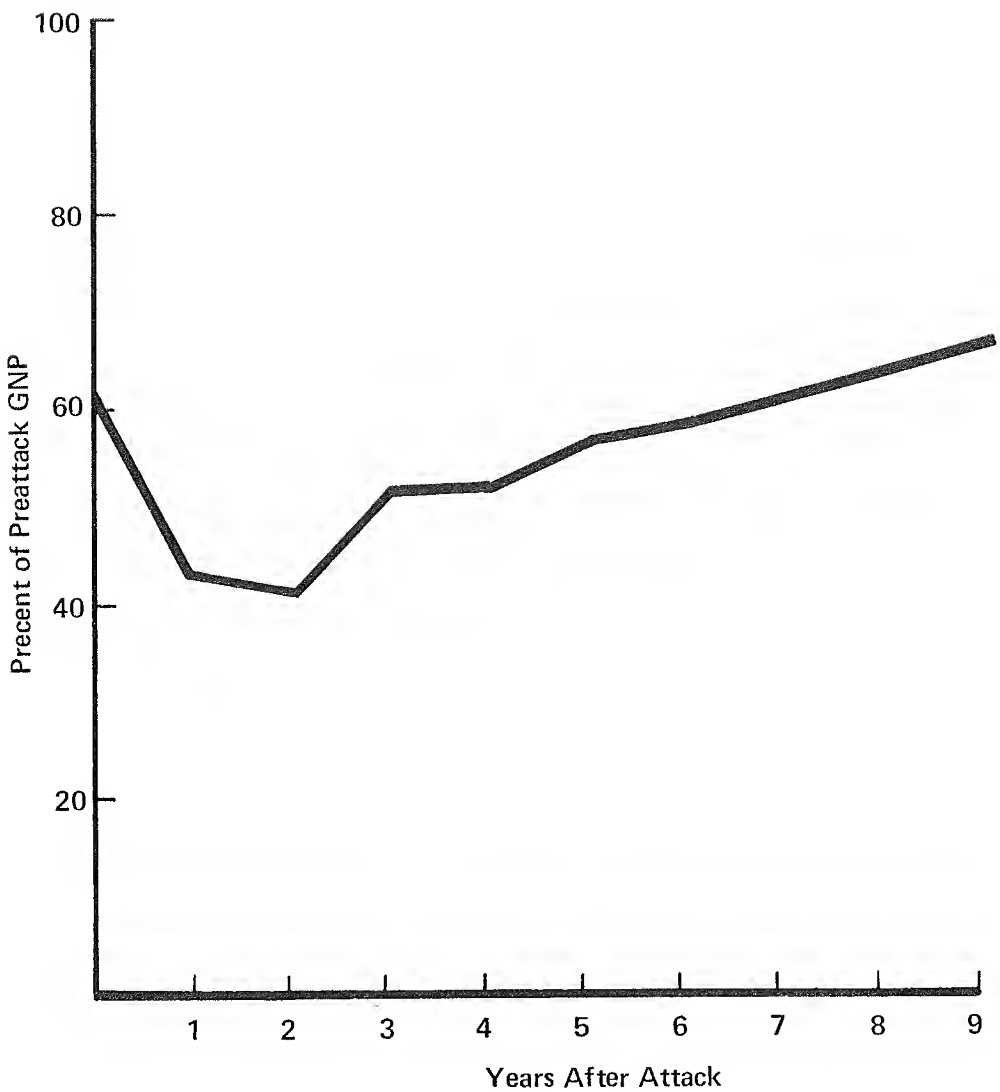
PANEL 9

HOUSING SPACE IN VARIOUS COUNTRIES*

Place	Persons per Room	Relative to U. S.
United States	0.6	1.0
Canada, United Kingdom	0.7	1.2
France, West Germany	0.9	1.5
Puerto Rico, Italy	1.1	1.8
Czechoslovakia, Finland	1.3	2.2
Soviet Union, Greece	1.5	2.5
Poland, Yugoslavia, China	1.7	2.8
India, Guatemala	2.6	4.3

* From United Nations Statistical Yearbook, 1971.

ONE PROJECTION OF ECONOMIC RECOVERY*



*From Dresch, F.W., and Baum, S., **Analysis of the U.S. and USSR Potential for Economic Recovery Following a Nuclear Attack,** Stanford Research Institute, October 1972 (AD 755 552).

CRISIS ACTIONS FOR ECONOMIC RECOVERY

A period of extreme crisis could provide both the time and the sense of urgency that would be necessary for taking action to improve the prospects for postattack economic recovery. Local government, working cooperatively with local industry, could make the essential peacetime plans without which the task of implementing crisis actions would be much more difficult. Mobilization during times of international tension is compatible with current estimates of a low probability of sudden attack (see Chapter 1).

Many major corporations have made peacetime arrangements for protected alternate corporate headquarters. In a crisis, most other businesses could relocate essential records and management personnel outside the large cities. Management will recognize such plans as insurance that they can "stay in business."

Hundreds of billions of dollars of economic assets are located in potential target areas in the form of finished inventories, parts, and specialized equipment. In a crisis, many of these resources could be loaded on trucks, railroad cars, and delivery vehicles and removed from the area where they could be placed in temporary open storage or parked in the loaded vehicles. Equipment and parts needed to sustain production, should this be necessary, could be buried later on the premises to protect them against blast and heat damage. This could be done in a few hours' time in many instances. Delicate and irreplaceable control equipment should be wrapped in plastic before burial. Machine tools and bulky equipment that cannot be moved can be made less vulnerable to damage by sandbagging and other protective measures so that they could be recovered even if the building is demolished. A large proportion of business assets could be preserved with the use of these measures.

Facilities outside the cities for bulk storage of fuels, chemicals, grains and other essential commodities could be brought at full capacity despite seasonal demands. As noted in the next panel, fuel, fertilizers, and pesticides will be of particular importance in assuring early recovery of agricultural production. Needless to say, expedient fallout shelter should be planned for at industrial and supply facilities that are intended for continued operation or for early postattack use.

Finally, government can contribute to early economic recovery by offering RADEF equipment and crisis training and by preparing plans and materials for implementing rationing and other control measures.

CRISIS PREPARATIONS*

- Remove records and management to safer locations.
- Relocate valuable equipment and inventories.
- Bury critical movable items.
- Protect machine tools and special equipment.
- Augment inventories of fuel, chemicals, and other stocks outside urban areas.
- Accelerate production and safe stockpiling of essential survival items.
- Provide shelter and alternate locations for work force and dependents.
- Expand RADEF capabilities outside urban areas.
- Mobilize postattack control measures.

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*Based in part on Rockett, F.C., and Brown, W.M., **Crisis Preparations for Postattack Economic Recovery**, Hudson Institute, July 1966 (AD 639 387).

AGRICULTURAL PRODUCTION

In his major study, **Economic Viability After Thermonuclear War: The Limits of Feasible Production**, Rand economist Sidney G. Winter, Jr., came to this conclusion: "If measures could be devised and preparations made to assure that agriculture would not be drastically altered, then it appears that all other economic problems could be managed." Dr. Winter was considering attacks of the size that could now be delivered at a time when lack of knowledge about fallout created a grave uncertainty as to how much farmland would remain suitable for growing crops. As discussed in Chapter 6, this is no longer believed to represent a serious problem. Nonetheless, recovery of agriculture remains crucial to post-attack viability.

In the United States, less than 5 percent of the population produces peacetime surpluses on a fraction of the arable land. This means that agriculture is dependent on other sectors of the economy to support its mechanized and intensive operations. The most critical needs are fuel and fertilizer. Without petroleum products, field crop production would be virtually impossible. All major food and feed crops are mechanically planted and harvested. Livestock, which accounts for nearly half the caloric value of the food produced, depends on the availability of feed, which is itself dependent on petroleum. The petroleum refining industry, which is highly concentrated, is potentially vulnerable. However, the use of farm machinery is seasonal and petroleum storage on or near farms is substantial. Post-attack, a greater share of the surviving fuel could be directed to agriculture and plans should be made to allocate petroleum to those areas where immediate use of machinery is essential and where high yields are to be expected.

It has been estimated that about one half of U.S. food production can be attributed to applied fertilizers. Lack of fertilizers can be accommodated partially by emphasizing crops and farm regions not requiring fertilizer and by bringing more land under cultivation. The latter course, however, requires more fuel. Nitrogen is the principal nutrient required. Nitrogen production facilities are located throughout the country and considerable excess capacity exists today. Sufficient production is expected to survive a major nuclear attack.

Major field crops are grown without pesticides in many places. Lack of pesticide availability would be most strongly felt in the yields of potatoes, fruits, and vegetables. Irrigation is also important for these crops, as well as for rice and sugar beets. Availability of electricity is most critical to dairy and poultry production.

Studies have shown that capabilities for transportation, storage, and food processing of basic agricultural commodities should survive as well or better than food production, except for wholesale warehousing. Good management, based on adequate plans, appears to be the key to recovery of food production.

CRITICAL NEEDS FOR FOOD PRODUCTION*

- Fuel and Lubricants
- Fertilizer
- Pesticides
- Seeds
- Irrigation and Drinking Water
- Equipment and Parts
- Feed
- Electricity
- Transportation, Storage, and Processing

*From Brown, S.L., et al., **Agricultural Vulnerability to Nuclear War,** Stanford Research Institute, February 1973. (AD 765 725)

ECOLOGICAL DEFENSE

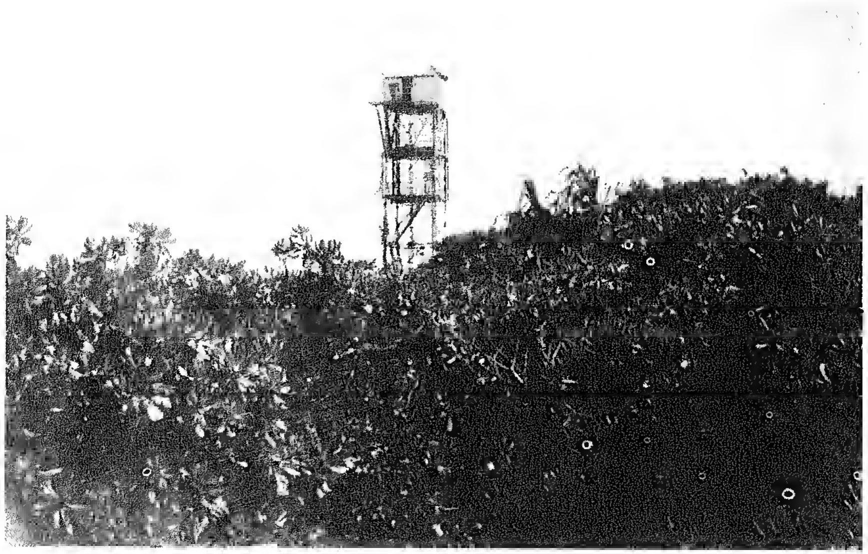
In Chapter 6, Panel 28, the possibilities of ecological catastrophe were discussed. Speculation that the attack environment might cause drastic upsets in the "balance of nature" have assumed that changes that exist for a relatively short time can induce permanent ecological damage. This is not borne out by experience. For example, some of the atolls in the South Pacific have experienced repeated direct effects and fallout from weapons tests comparable to the worst that could occur in a nuclear war. As these illustrations show, the tropical ecosystem has survived and recovered. The native population has returned to live on Bikini and Rongelap Atolls. Long-term consequences require continuous pressure over centuries of time, of which the impact of human habitation is the outstanding example.

Some significant consequences that may well occur as part of the post-shelter environment are also discussed in Chapter 6. These potential ecological consequences (one cooler growing season, temporarily increased rainfall, fire in dead pine forests, increased erosion and silting, and outbreaks of insect and rodent pests) could have an indirect effect on agriculture and forestry.

Trees, especially pines, are vulnerable to fallout radiation. The loss of a forest can be regained only after many decades. Dead trees are a valuable resource for wood products if they are harvested. If not harvested, they become a refuge for insect pests and plant diseases. They become a fire hazard. Forest fires destroy both trees and ground litter, resulting in increased surface runoff and erosion, excessive silting of streams, reservoirs, and irrigation works, loss of water for crops, and loss of crop yield. Prompt harvesting and reforestation are postattack actions needed to control these consequences.

Fallout radiation effects on insects and wild animals could affect agricultural production. For example, bees are essential to the pollination of certain agricultural crops, particularly fruits. A large reduction in the natural population of birds and preying insects could produce severe crop infestation by parasitic insects. But man is not helpless. He can move bee colonies where they are needed. He can import or otherwise assist the repopulation of fallout areas with beneficial species. All of these actions could well be called, "ecological defense."

Bikini Island, November 1955



View of same area as above in 1967. Some coconut trees had reached 20 feet and were bearing fruit.

RADIATION EXPOSURE CONTROL

The final barriers to recovery that the survivors must surmount are the possible late somatic and genetic effects of irradiation discussed in Chapters 5 and 6. The key to these problems is good radiation exposure control. Exposure control in the post-shelter environment will be greatly aided by the advice of trained Radiological Defense Officers.

Exposure control begins, however, with effective warning and sheltering of the population at the time of attack. Effective sheltering involves the use of the best available fallout shelter, not just those that meet some minimum criterion, such as PF 40. That is, the planner must be concerned not only with preventing lethal exposures but also with keeping the radiation burden of the survivors as low as possible. To this end, a protection factor of 400 is vastly better than a protection factor of 40. Crisis plans to build expedient shelters (Chapter 7) and to improve the protection in existing shelter areas can contribute to exposure control.

People should be encouraged and instructed to remain in shelter as long as possible in fallout areas. Naturally, this advice must be balanced against the need to get on with the urgent tasks of recovery. But many, especially children, are not needed for these early tasks outside. Children and young adults should be given maximum protection to minimize genetic damage in subsequent generations. Late radiation injury is of minimal concern to those over 40 years of age. Even so, the shelter areas should be used as off-duty quarters for the workers.

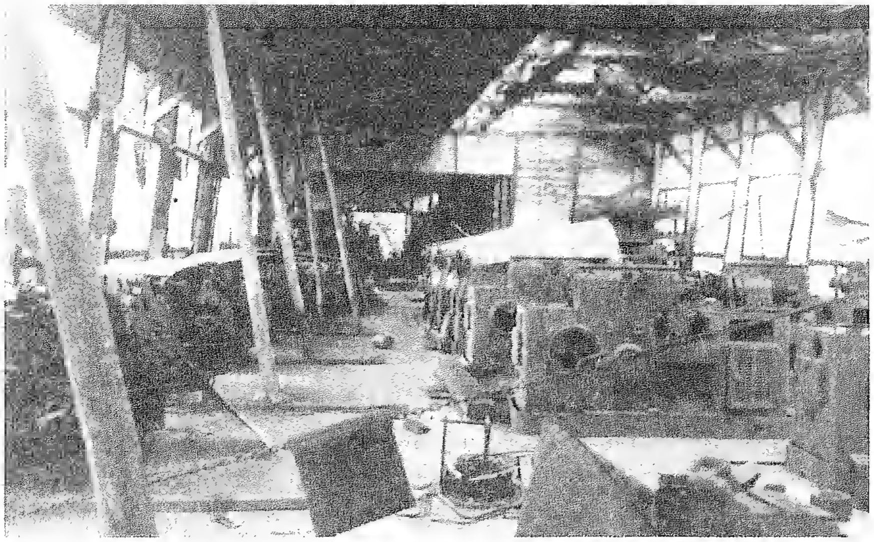
An important control measure during the first month after attack will be to limit the intake of radioactive iodine by children (see Chapter 6, Panel 25). They should be provided with stocked water or water from wells or areas of low contamination and kept from drinking contaminated milk.

Even in areas of moderate fallout, decontamination will be important to limit the continued exposure to radiation over the months and years ahead. In the process, the necessary radiation exposure should be spread among the able-bodied survivors by rotation and work shifts so that the radiation burden of individuals is kept as low as possible.

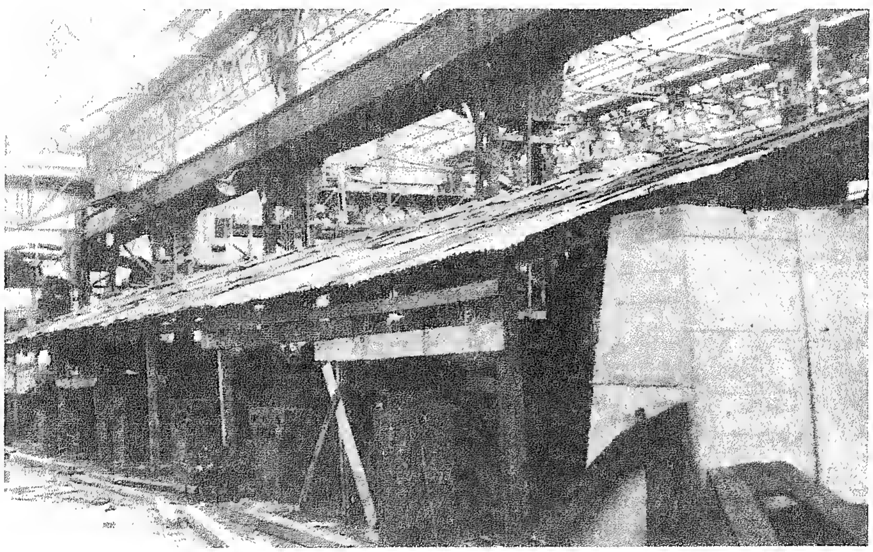
ELEMENTS OF EXPOSURE CONTROL

- Make sure there is a RADEF person on the staff who is well-trained and qualified.
- Make use of <u>best</u> available fallout shelter.
- Keep the population in shelter as long as possible.
- Preferentially protect children and young adults.
- Use shelters for lodging after "shelter emergence."
- Provide children with uncontaminated drinking water for the first month.
- Decontaminate living and working areas.
- Spread the necessary radiation exposure among the work force.
- Keep on decontaminating.

PANEL 23



Undamaged machine tools at Hiroshima. Sheet metal is being used to protect against weathering.



Arrangement of temporary weather protection in Nagasaki industrial plant.

POSTNUCLEAR ATTACK STUDIES

			ESTIMATED LOSSES	
STUDY	YEAR	FOR	POPULATION	INDUSTRY
The Rand Study	1958	USAF	35%	55%
The SRI Study	1963	DoD	42%	45%
PAVUS-75	1967	Army	45%	35%
DAL-67	1967	DoD	45%	42%
PONAST II	1973	JCS	46%* 11%**	63%

* With present civil preparedness capability.
** With crisis relocation and expedient fallout shelter.

SUGGESTED ADDITIONAL READING

Proceedings of the 1967 Symposium on Postattack Recovery from Nuclear War, National Academy of Sciences, April 1968. (AD 672 770)

Goen, R.L., **The Magnitude of Initial Postattack Recovery Activities**, Stanford Research Institute, December 1971. (AD 741 389)

Bensen, D.W., and Sparrow, A.H., **Survival of Food Crops and Livestock in the Event of Nuclear War**, U.S. Atomic Energy Commission, December 1971. (CONF 700-909)

Van Horn, W.H., et al., **Repair and Reclamation of Gas and Electric Utility Systems**, URS Research Co., July 1967. (AD 665 307)

Walker, F.E., **Estimating Production and Repair Effort in Blast-Damaged Petroleum Refineries**, Stanford Research Institute, July 1969. (AD 697 717)

Staackmann, M., et al., **Damage to the Drug Industry from Nuclear Attack and Resulting Requirements for Repair and Reclamation**, URS Research Co., July 1970. (AD 714 304)

Fernald, O.H., **Critical Industry Repair Analysis, Food Industry**, Advance Research, Inc., April 1965. (AD 614 908)

Pyecha, J.N., et al., **Postattack Medical Care Measures of Effectiveness**, Research Triangle Institute, September 1971. (AD 730 945)

PHOENIX RISING FROM THE ASHES

PANEL 31

CPG 2-1A9
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DCPA ATTACK ENVIRONMENT MANUAL

CHAPTER 9

APPLICATION TO EMERGENCY OPERATIONS PLANNING

DEFENSE CIVIL PREPAREDNESS AGENCY
DEPARTMENT OF DEFENSE

JUNE 1973

"Plans are worthless, but planning is everything. . . . keep yourself steeped in the character of the problem you may one day be called upon to solve--or to help to solve."

President Dwight D. Eisenhower, 1957

THE UNCERTAINTIES OF RISK

Chapter 1 also emphasized the need for contingency planning to develop operational readiness in each locality to cope with the range of attack environments that could reasonably occur. Subsequent chapters made clear that in areas remote from the sites of nuclear detonations, only fallout was a hazard to life and EMP a threat to electronic and electrical equipment. The direct effects of nearby detonations—blast, fire, and initial nuclear radiation—posed a threat as well. Nuclear emergency operations would be more complex and demanding in these "risk" areas.

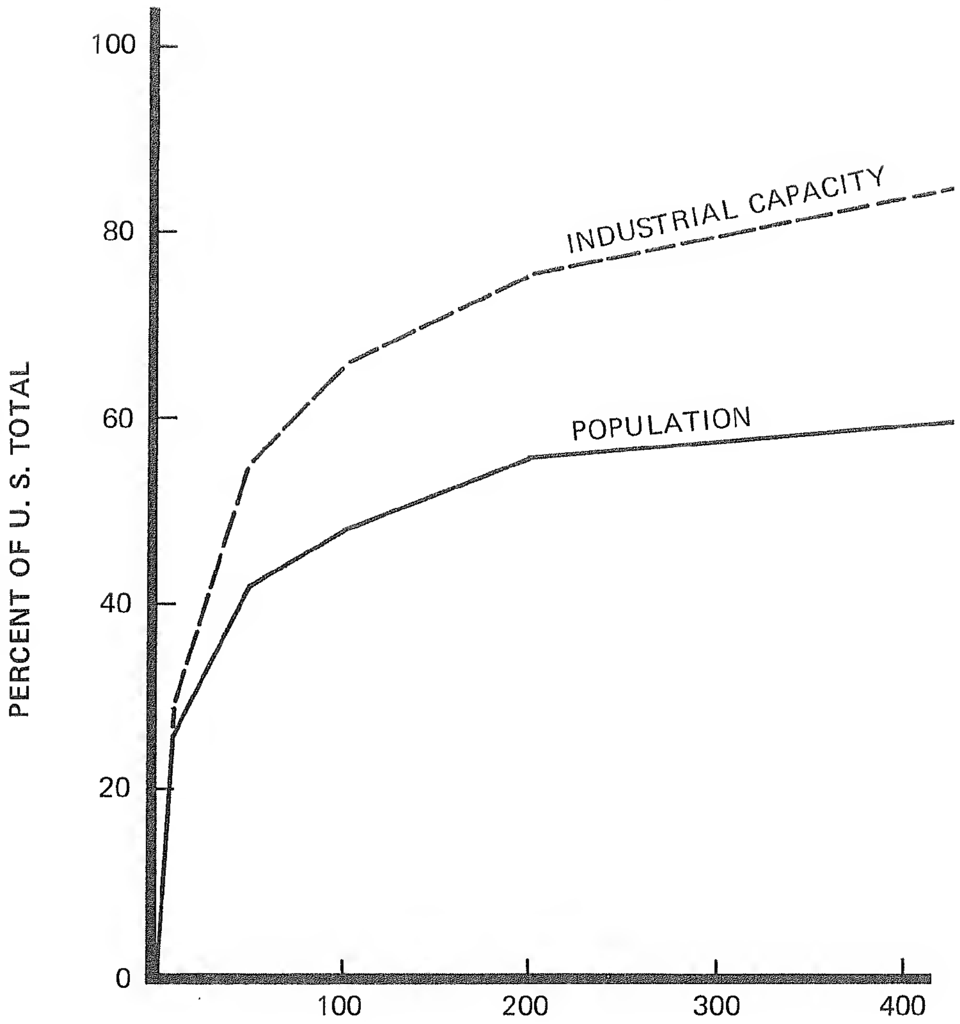
It would be advantageous to know in advance where nuclear detonations will occur in event of war. Emergency planning would be much simpler. But the uncertainties will not permit more than a judgment that some localities are more at risk than others, and, of course, no weapon has been made perfectly reliable or accurate. Hence, no place can be "written off" as certain of devastation. For another thing, we do not know how many enemy weapons would be burst on or near the surface. Hence, we do not know how severe the fallout threat will turn out to be. Of course, we do not know what the winds will be like and, thus, where the significant fallout will occur. And, finally, we do not know what targets an enemy will select.

Perhaps the most authoritative statement of Soviet targeting doctrine is contained in the Russian book, **Military Strategy**, by Marshal V.D. Sokolovsky, where it is stated:

> "The targets in a modern war will be the enemy's nuclear weapons, his economy, his system of government and military control, and also his army groups and his navy in the theaters of military operation."

This listing is repeated several times in this book. People as such are never mentioned as a legitimate target. But, as this chart shows, U.S. industry is mainly located in the larger cities—and that is where much of the population lives as well. That is why it was argued in Chapter 1, Panel 14, that all localities needed to plan for the possibility of potentially serious fallout radiation exposure, and those near important military and industrial facilities needed to plan for direct weapons effects as well.

INDUSTRIAL CONCENTRATION



Number of U.S. populated areas.
(Ranked by population from largest to smaller.)

PANEL 2

BRAVO COMES AFTER ALFA

ALFA is the first letter in the international phonetic alphabet. BRAVO is the second letter. We use ALFA to denote an emergency plan based on protecting the population in place—where they normally live. BRAVO plans are based on relocating masses of the population from the places of highest risk (cities, in nuclear attack planning; coastal areas in hurricane planning) in advance of attack or disaster. This table shows how the population might be located if a BRAVO relocation had occurred as compared with that shown in Chapter 1, Panel 14. Clearly, preattack dispersal and evacuation could save millions of lives.

Evacuation was the basic civil defense plan in the 1950s when nuclear weapons could be delivered only by bomber aircraft. Several hours could be expected after detection of the aircraft before nuclear detonations could occur in U.S. cities. Evacuation planning concentrated on means to move city-dwellers out of the cities during this short time interval. The deployment of ballistic missiles made evacuation after attack warning impractical, and means for protection of the population in-place were given much consideration.

By the time of the Cuban Missile Crisis of 1962, it had become accepted that a "bolt-out-of-the-blue" surprise attack was highly unlikely. Evacuation of cities during a crisis appeared feasible. But planning for this contingency was de-emphasized because strategic warning indicators were notoriously ambiguous, and because a decision to evacuate cities might not be compatible with the President's objective of resolving the crisis short of nuclear conflict.

However, in the past few years, crisis evacuation has emerged as the basis for Soviet civil defense. Other countries, such as Sweden and Norway, publish evacuation and other defense plans in their telephone books as guidance for the populace. Plans to evacuate our cities if the Soviets should do so—BRAVO plans—are now important if the President is to have additional time to negotiate the differences that generated the crisis. Nonetheless, the carrying-out of such plans will remain uncertain. Therefore, the strategy of protection in place, by shelter in existing buildings, remains the primary basis for nuclear emergency operations planning and will be considered first in this chapter. That is, A comes before B!